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August 10, 2012

Robert G. McCoy, Esq.
Cascino Vaughan Law Offices, LTD.
220 South Ashland
Chicago, Illinois 60607-5308

Re: AHNERT, et al. v. CBS CORPORATION, et al.
Civil Action No. MDL 875
GHP Project #11266.55

Dear Mr. McCoy:

This report contains the background materials and opinions of Gobbell Hays Partners, Inc. (GHP) for the above referenced case. This report contains an Introduction and Case Specific Materials Reviewed in Formulating Opinions, Work History, Occupational Exposure, and Opinions.

I. INTRODUCTION AND CASE-SPECIFIC MATERIAL:

This report is based on a review of the depositions given by John Burns, December 19, 2011, and John Shorougian, March 27, 2012, case specific documents provided by Cascino Vaughan Law Offices, LTD., the documents, literature, and our qualifications and experience as Environmental Scientists and Industrial Hygienists. We also relied on our general knowledge in the topic areas, including GHP's General Asbestos Exposure Report, up-dated May 1, 2012, and library of relevant publications listed in the general report. Our opinion may be supplemented or changed if new evidence/information is presented.

In the process of preparing this report, we have relied on the following case specific materials and assumptions that have been provided by Cascino Vaughan Law Offices, LTD: 1) The Requirements of Federal Rules of Civil Procedure 26(a)(2)(B); 2) List of defendants remaining; 3) List of Plaintiff work sites; 4) Summary of the deposition of John Burns, December 19, 2011; 5) Summary of the deposition of John Shorougian, March 27, 2012; 6) Surgical Pathology Report, January 4, 2011; 7) Deposition of John Burns, December 19, 2011; and 8) Deposition of John Shorougian, March 27, 2012.

II. WORK HISTORY:

According to the deposition of **John Burns, December 19, 2011:**

Mr. Burns worked as a steamfitter from 1952 to 1995 as a member of Steamfitters Local 601 of Milwaukee (9:6-14). Mr. Ahnert was also a steamfitter and a member of Local 601 (10:21-23; 53:14-16). They worked together on various jobs for Milwaukee Public School District (11:9-13) In the early '60s (15:4-8), Mr. Burns worked with Mr. Ahnert for the Milwaukee Public School District at about six (13:21-14:1) or three (45:13-16) different schools over a period of 2-3 years (52:2-6). They worked together for a total of about a month (52:13-25).

According to the deposition of **John Shorougian, March 27, 2012:**

Mr. Shorougian was a member of Steamfitters local 601 based out of Milwaukee, Wisconsin for 33 years (6:18-24). Mr. Shorougian worked with Mr. Ahnert at Oak Creek Power Station in the early to mid-1980s for about six months (5:25-6:7). They worked overtime and Saturdays (20:17-24). Mr. Shorougian was Mr. Ahnert's partner for most of the job (6:24-7:1). They worked a few feet away from each other most of the time (20:4-7). The subcontractor both men worked for at Oak Creek Power Station was Foster Wheeler (23:8-11).

III. OCCUPATIONAL EXPOSURE:

The facts, data, and assumptions supplied by counsel concerning Mr. Ahnert's exposure to asbestos-containing thermal systems insulation, drywall joint compound, and gaskets are reliable. Also, that:

- "Mr. Ahnert worked in close proximity to other tradesmen mixing insulating cement and cutting molded or block insulation for use on thermal systems on multiple occasions in the 1960s and 1970s. He also removed, and worked in close proximity to other tradesmen removing, these insulation products from thermal systems on multiple occasions, including without limitation during the 1960s and 1970s.
- Mr. Ahnert worked in close proximity to other tradesmen mixing and sanding drywall joint compound on multiple occasions in the 1960s and 1970s.
- Mr. Ahnert removed gaskets from thermal systems, and worked in close proximity to other tradesmen doing the same, on multiple occasions in the 1960s, 1970s, and 1980s."

According to the deposition of **John Burns, December 19, 2011:**

At Milwaukee Public School District, Mr. Burns connected steam lines to Cleaver-Brooks boilers (11:17-25). Mr. Ahnert did welding about 5-10 feet from boilers (13:9-18). They opened up the boilers to do work on them; this was a dusty process (16:12-15).

Mr. Burns testified that Sprinkmann, L&S Insulation, and Milwaukee Insulation were all insulation contractors for the Milwaukee schools (16:24-17:9). Mr. Burns saw Sprinkmann more than the other two (17:22-18:2). These contractors used Kaylo and Carey insulation, among other brands (18:4-11). Mr. Burns saw Sprinkmann employees installing block insulation (21:4-5). A considerable amount of insulation work was being done on the pipes that they installed (16:25-17:2). Rooms at the schools where Mr. Burns and Mr. Ahnert worked were very dusty (19:16-21).

Mr. Burns testified that drywall work was done at the Milwaukee schools; brands of joint compound used included Georgia-Pacific (23:6-12). The Georgia-Pacific joint compound was mixed with water in five-gallon pails (23:21-25). He saw bags of joint compound with the Georgia-Pacific label (84:9- 11).

They didn’t wear masks at Milwaukee Public School District (20:4-5).

According to the deposition of **John Shorougian, March 27, 2012:**

Mr. Shorougian testified that while they worked at Oak Creek Power Station, Mr. Shorougian and Mr. Ahnert worked on Unit 5 burner deck (6:8-12). The boiler was about 100 feet tall, 50 feet long, and 50 feet wide and he believes it was a Foster Wheeler boiler (6:13-21). They were present for the tear-down of the boiler, which involved the removal of insulation material (7:12-23). WEPCO, Wisconsin Electric Power Company, employees told them that the insulation was not asbestos (9:4-9). Members of his union had it tested, and it tested positive for asbestos (12:11-22). Sprinkmann was the insulating contractor at Oak Creek Power Station, and Sprinkmann employees were removing some of the insulation from the boiler (11:3-8). Sprinkmann employees were there every day (16:7-10). The environment at Oak Creek Power Station was always dusty, and both Mr. Shorougian and Mr. Ahnert breathed in dust from this boiler work (11:18-12:2). He believes that dust from the boiler work was in the air the entire six months that they worked there (19:18-25).

Mr. Shorougian testified that, they both removed gaskets from the boiler (14:14-15:3). Mr. Shorougian and Mr. Ahnert removed the gaskets by scraping them with a wire bush, scraper, or grinder with a wire wheel (15:4-14). This was dusty work, and they breathed in some of

the dust (15:15-16:6). They removed about 16 gaskets from the boiler itself (74:2-10). Removing each gasket took about an hour (74:14-18).

IV. OPINIONS:

Based on the information detailed above, we have been asked to evaluate Mr. Ahnert's exposures to asbestos-containing thermal systems insulation, drywall joint compound, and gaskets. As to those exposures, we provide the following opinions.

A. Daniel Ahnert's career is summarized in Section II of this report. As detailed in Section III, during his career he worked with and around these types of products. Based on the facts, data, and assumptions, these products were asbestos-containing or asbestos insulated during the period of Mr. Ahnert's work.

B. Significant exposure to asbestos includes the installation, removal, cutting, manipulation, repairing, or in any way disturbing of an asbestos-containing product in such a manner that airborne asbestos fiber concentration is released above background concentration. ATSDR reports asbestos background as a range between 10^{-8} to 10^{-4} PCM f/ml.

C. When the asbestos products were installed, removed, cut, manipulated, repaired, or in any way disturbed, Mr. Ahnert, while working with such products or as a bystander, was exposed to significant airborne concentrations of asbestos for each type of product.

D. Airborne asbestos does not settle quickly from the air and can easily become re-entrained after it does settle.

E. Since the 1930's, working with or around hazardous contaminants in the work place, the need for appropriate training, appropriate respiratory protection, and adequate engineering controls were recommended. Asbestos was included among these workplace hazards. Good industrial hygiene practices would have included warnings.

F. We found no evidence of the use of appropriate training, appropriate respiratory protection, or adequate engineering controls. Appropriate training, appropriate respiratory protective equipment, and adequate engineering controls will reduce the exposure to airborne asbestos.

G. The dangers of exposure to asbestos-containing products have been well documented in the scientific literature. By 1938, asbestosis had been thoroughly documented, and by 1955, the link between asbestos and lung cancer had been firmly established in public health and industrial safety literature.

We declare under penalty of perjury that the foregoing is true and correct.

Stephen Kenoyer
Environmental Scientist, MS
Industrial Hygienist

Kenneth S. Garza, CIH, MS

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Nashville
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General Asbestos Exposure Report of Kenneth S. Garza and Stephen Kenoyer

May 1, 2012

(Amended January 21, 2013)

Federal Rule 26

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Index to General Asbestos Exposure Report of
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General Asbestos Exposure Report of Kenneth S. Garza and Stephen Kenoyer,

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Federal Rule 26

1. Introduction

This report is based on a review of pertinent literature and exposure assessment studies cited in this report and our qualifications and experience as Environmental Scientists and Industrial Hygienists. Selected industrial hygiene, scientific, and regulatory publications upon which we relied are cited in Appendix A. Our curricula vitae are in Appendix B. Our expert testimony history is given in Appendix C. Our compensation is given in Appendix D. We also relied on our general knowledge in the topic areas, including our library of relevant publications. Our opinions may be supplemented or changed if new evidence/information is presented to us.

The purpose of this report is to provide industrial hygiene opinions about 1) exposure and potential exposure to airborne asbestos, 2) as well as specific exposures from various asbestos-containing products (Sections 8-20).

“Asbestos has been used in cement products, plaster, fireproof textiles, vinyl floor tiles, thermal and acoustical insulation, and sprayed materials.” (EPA, 1979) “Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate and are resistant to heat, fire, chemical and biological degradation… As a result of its low cost and desirable properties such as heat and fire resistance, wear and friction characteristics, tensile strength, heat, electrical and sound insulation, adsorption capacity, and resistance to chemical and biological attack, asbestos has been used in a very large number of applications and types of products.” (ATSDR, 2001)

2. Industrial Hygiene

Historic exposures were mostly measured using an impinger, which gave results in million particles per cubic foot of air (mppcf), or using phase contrast microscopy (PCM) to examine sampling filters, which is an optical microscopy technique that gave results in fibers per cubic centimeter of air (f/cm^3). It should be noted that units "f/cc" or "f/cm^3" (fibers per cubic centimeters) and "f/ml" (fibers per milliliter), have the same quantitative meaning. The PCM method measures only fibers equal to or longer than 5 micrometers, with an aspect ratio (length to width) of equal to or greater than 3 to 1. Short fibers are not counted, and thin fibers are not even seen by the analyst because the optical scope cannot resolve fiber widths less than 0.25 micrometers. The mppcf measurement gives no information about fiber size, large or small, since it only provides a total numerical count of dust particles present. With these historic data, and with contemporary PCM data, the total number of fibers present and the fiber size distribution are not known. Transmission electron microscopy (TEM) is another and more current method of analysis. This approach is appealing because it quantitatively measures only airborne asbestos fibers and reports them in structures per cubic centimeter (s/cc). This method can also distinguish between the different types of asbestos. Using historic data on average exposures or ranges of exposures in a given operation or job to estimate exposures for an individual or a cohort must be done with these limitations and/or capabilities in mind.

Exposures in any individual case are influenced by many variables. These include, but are not limited to, the work being done, the particular method by which the work is done, ventilation (mechanical or natural), air flow patterns and characteristics, types of asbestos-containing products, proximity to the work, duration of the work, and duration of fiber settling times. Given these variables, it is logical that an individual's exposure profile may have a broad range for any given time period or job, and certainly for a career. Indeed, the fact that the average exposure for a particular trade or job may be low does not mean that the exposure was low for every worker in that trade or for every worker doing a particular task. Historic and contemporary data confirm this variability.

For industrial hygiene purposes, ranges are often more useful in understanding exposure than are averages. Air samples are integrated over the time periods of the individual samples, so there can be a range of exposure within each individual air sample that is unknown. For example, if an air sample is taken for 4 hours (240 minutes) and the reported result is 1.0 f/cm^3, that number could represent 30 minutes at 5.0 f/cm^3 (500% of the reported result) and 210 minutes at 0.4 f/cm^3 (40% of the reported result). The possibilities for the range of exposures are many for every air sample. Instantaneous, real time measurements specific to asbestos were not, and are not, done. Hence, exposure is affected by the workplace variables mentioned above, and the assessment of exposure is affected by the measurement techniques themselves. The full range of exposures even for a given workplace may not be known if both the highest and lowest concentrations were not measured, and even if the extremes were measured the data are subject to the limitations of the integrated sampling methodology. The variables in the workplace and limitations in the sampling methodology must be understood to prevent bias in interpretation of data and studies.

Historical exposure data are limited in quantity and scope. It is unreasonable to assert that such historical data, simulation data, etc. can only be reliable for estimating exposures that match in every detail the historical events, the simulations, etc. It is standard industrial hygiene practice to consider, with appropriate care, all data which may have bearing on a worker's exposure. If industrial hygiene were limited to estimating exposures only where historical data existed as an exact match for the situation under assessment, there would be no meaningful and practical way to predict average exposures and/or ranges of exposures for the boundless variety of work places, work practices, and products in commerce today and historically. Without exposure estimates (both retrospective and prospective), health effects could not be related to workplace conditions, adequate exposure limits could not be established, and epidemiology studies would have insufficient foundation related to environmental conditions. This situation would preclude adequate worker protection and make workers "canaries" like those birds used in coal mines in times past.

3. Regulations and Literature

In 1971, the US Occupational Safety & Health Agency (OSHA) published its first asbestos regulation. In 1971, the US Environmental Protection Agency (EPA) listed asbestos as a hazardous air pollutant.

OSHA's first asbestos exposure standard in 1971, was 5 fibers per cubic centimeter of air (f/cc). The permissible exposure limit (PEL) has been reduced several times since to the current limit of 0.1 f/cc for an 8-hr time weighted average (TWA) and 1.0 f/cc over a 30 minute sampling time (Excursion Limit). Even this current PEL is not considered by OSHA to be fully protective and is still considered "a significant risk." (OSHA FR, 1994) OSHA regulates all forms of asbestos minerals (chrysotile, amosite, etc.) in the same manner because all types are known to cause disease, and the EPA also regulates all asbestos types in the same way.

The American Conference of Governmental Industrial Hygienists (ACGIH) in 1946 published its recommended exposure standard for asbestos. The standard was called a maximum allowable concentration (MAC) and was set at 5 million particles per cubic foot (mppcf) as an 8-hr TWA. (ACGIH TLV, 1946-1991) This measurement was by use of an impinger, and the analytical result was reported as the number of counted dust particles, per volume of air, collected in the impinger. The adequacy of the ACGIH MAC, which remained at 5 mppcf through 1973, was called into question in the literature in 1964. (Marr, 1964) In 1968, two published articles concluded that the MAC was too high. (Balzer, Environment, 1968) (Balzer, Industrial Hygiene, 1968) The ACGIH standard, which is now called the threshold limit value (TLV), has been reduced many times since and is currently at 0.1 f/cc as an 8-hr TWA. This measurement is specific to fibers, rather than all dust; however, the technique does not distinguish asbestos from non-asbestos fibers. The ACGIH definition of the TLV is "the time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that ***nearly all*** workers may be repeatedly exposed, day after day, without adverse effect." {emphasis added} (ACGIH 2006)

The EPA recognizes the concept of friability relative to the exposure risk associated with in-place asbestos-containing materials (ACMs). The agency's regulations for demolition and renovation require methods to control the release of fibers to the environment when ACMs to be disturbed are friable in-place and when ACMs which are not friable in-place will be rendered friable by the intended disturbance. ACM will release asbestos fibers into the air when it "…has deteriorated or sustained physical injury such that the internal structure (cohesion) of the material is inadequate or, if applicable, which has delaminated such that its bond to the substrate (adhesion) is inadequate or which for any other reason lacks fiber cohesion or adhesion qualities. Such damage or deterioration may be illustrated by the separation of ACM into layers; separation of ACM from the substrate; flaking, blistering, or crumbling of the ACM surface; water damage; significant or repeated water stains, scrapes, gouges, mars or other signs of physical injury on the ACM." (EPA, How to Manage, 1996) {ACBM= asbestos-containing building material}

4. Airborne Asbestos Hazard

Industrial hygienists use many techniques to assess exposure when little or no data exist for a given situation or worker. Conclusions may be drawn from data in the literature if conditions have sufficient similarity to the case of interest. Simulations are reliable for estimating exposure. (DiNardi, 2003) These data sources can be used to establish a likely range of exposures and probable average. For a given worker, however, the actual exposures at the extremes may be more or less than studies and literature indicate. General conclusions about exposures of a given worker population may not be accurate for an individual worker.

Industrial hygienists also may use retrospective exposure modeling for a given situation where actual data do not exist. This mathematical approach requires the use of many assumptions about what actually happened in the workplace and must also rely on studies and/or data collected under similar circumstances.

As noted above, OSHA does not consider the current PEL's to be fully protective. "OSHA's risk assessment also showed that reducing exposure to 0.1 f/cc would further reduce, but not

eliminate, significant risk." (OSHA FR, 1994) "No safe limit or 'threshold' of exposure is known. Any exposure to asbestos carries some risk to health, and people exposed to low levels of asbestos for a very brief period have later contracted mesothelioma." (EPA, 1980) Various cancers, including mesothelioma, are known to be caused by asbestos at very low lifetime doses. (Hillerdahl, 1999) (Goldberg, 2005) (Rodelsperger, 2001) (Iwatsubo, 1998) In a review from Dodson, "[t]he WHO stated that '[T]he human evidence has not demonstrated that there is a threshold exposure level for lung cancer or mesothelioma, below which exposure to asbestos dust would not be free of hazard to health.' The International Programme for Chemical Safety (IPCS) has reiterated this position." (Dodson, 2006) Also, "…exposure levels below those allowed for asbestos workers, the risk of asbestosis is negligible. Some scarring of lung tissue may appear on X-rays after many years of low exposure, but no impairment of respiratory function is likely to occur. **However**, the incidence of lung cancer and mesothelioma exceeds baseline rates even at very low exposure levels." (USEPA, 1983) {emphasis added} "While lowering exposure lowers risk, there is no known level of exposure to asbestos below which health effects do not occur…Mesothelioma is a type of fatal cancer of the lining of the chest or abdominal cavity. It can be caused by very low exposures to asbestos. This cancer has occurred among brake mechanics their wives and their children." (EPA, Brake Mechanics, 1986) The WHO concludes there is no threshold exposure level below which exposure to asbestos dust would be free of hazard to health. (IPCS, WHO, 1998) (WHO, 2006) In a 1991 joint EPA and National Institute of Occupational Safety and Health (NIOSH) document, "NIOSH contends that there is no safe airborne fiber concentration for asbestos. NIOSH therefore believes that any detectable concentration of asbestos in the workplace warrants further evaluation and, if necessary, the implementation of measures to reduce exposures." (EPA, Building Air, 1991) "Avoiding unnecessary exposure to asbestos is prudent." (EPA, Guidance for controlling, 1985) "The results of numerous measurements indicate that average concentrations of asbestos in ambient outdoor air are within the range of $10^{-8} – 10^{-4}$ PCM f/mL..." (ATSDR, 2001) It is our opinion that there is no basis for accepting any workplace or non-occupational exposure to asbestos above ambient background as "safe."

The hazard of workplace dust, including asbestos, has been recognized since the 1930s, and engineering controls, proper exhaust ventilation, and respirator protection were recommended. National Safety News, August 1933, The Mechanical Control of Occupational Diseases, David S. Beyer, states that "[w]hen the subject of dust is mentioned most of us probably think of visible particles. In fact, much of the dust removal work, even by companies specializing along this line in the past has been directed at the form of dust…Medical research has shown us, however, that dust that is most dangerous through its deep into the lungs is so small that the individual particles are invisible and can only be seen by the naked eye if they are gathered in a dense cloud, which may have the appearance of a gray fog…In general, the most reliable way to correct a dust hazard is to install exhaust equipment that will capture the dust at the point where it is generated." TRANSACTIONS, 26th National Safety Congress, 1937: What Industrial Dusts Are Harmful? Why? Dr. R.R. Sayers, states that "Dust Control. Engineering and medical control are the two most important factors in combating the industrial dust hazard, and are to a large extent complementary…Dust may be entrapped at its source by suction devices and thus removed and collected…Generally speaking, the exhaust ventilation method, where applicable, is to be preferred in controlling a dust hazard…Sometimes a dusty process can be completely enclosed in a sealed room or compartment…A great deal of attention has been given the subject of individual protection from dust, and there are many types of respiratory protective devices now available. These are generally of two types: those which provide fresh air from an uncontaminated source and those which rely upon a filtering medium for removing dust from the air breathed. Where the use of such a device is indicated, only one of the types approved by the U.S. Bureau of Mines should be used. As a rule, it may be said that masks, respirators, or other such protective device should be used only where exposure to the dust is intermittent and brief, or where some unusual conditions makes a more adequate dust control impracticable." TRANSACTIONS, 32nd National Safety Congress, Volume II, 1943, The Control of Fumes in Shipyards, William E. Lawrence, states that "[t]he use of water repellent asbestos insulation has recently replaced some types of material formerly used in ship work. For protection against dust or possible asbestosis from such material, it is recommended that both on ships and in shops, or where the materials is prepared, it be dampened and that dust respirators be worn, also that special ventilation be provided. Periodic

medical examination of those exposed to such hazards is also necessary." (National Safety Council -Asbestos -1934-1949)

We believe that any exposure above ambient background is to be avoided and any such exposure may contribute to disease in some individuals. The human respiratory system is not selective as to the source (product) of airborne asbestos during inhalation; therefore, if there actually is a lifetime dose-response relationship for some diseases, any asbestos body burden added by workplace exposure above ambient contributes to risk of disease, regardless of the product types, manufacturers, worksites, or exposure averages. If no safe threshold exists for some asbestos-related conditions, such as mesothelioma, then the conclusion is the same.

5. Asbestos-containing Dust and Resuspension

Depending on the percentage of asbestos in the product and the force imparted to it, resultant dust will contain varying levels of asbestos. If a dust cloud is visible to the unaided eye, then the airborne concentration is well above 5 mppcf. (Dement Deposition, February 1998) Conversely, airborne asbestos concentrations can be very high even if dust is not visible in the air. "Usually the dust concentration must be from 8-10 million particles per cubic foot before its presence is visible in average lighting conditions." (Calidria, 1968) Like most other breathable hazards, concentrations of airborne asbestos can be decreased or increased due to particular prevailing conditions such as presence of ventilation, airflow, atmospheric conditions, amount of asbestos in the product used or disturbed, presence of other co-workers pursuing the same asbestos-related activity, workers' proximity to asbestos-related activity, and the sometimes numerous and different work practice approaches to the same asbestos-related activity.

According to the EPA, "The aerodynamic behavior of fibrous-shaped aerosol particles is governed by the interaction of opposing forces: a driving force such as is caused by gravitational acceleration, and the viscous resistant of the gaseous medium within which the particle moves." (EPA, ACM in Buildings, 1978) Asbestos fibers are very small and possess aerodynamic qualities such that the fibers, once released to the air, may remain suspended for hours, and hence remain

in the breathing zone of workers and bystanders. “It is of interest to note that for fibers whose diameter is of the order of 0.1μm, gravitational sedimentation occurs at the rate of only a few centimeters per hour, even though their length may be as much as 100μm.” (EPA, ACM in Buildings, 1978) The fibers may be carried by air currents to great distances from the original point of release. Fibers may eventually settle onto surfaces in the work area (either near or far from the release point, depending on air movement), and can be resuspended into the air when the surfaces onto which they settled are disturbed. This repeatable process can lead to very high airborne asbestos exposures. (EPA, ACM in Buildings, 1978) (Millette and Hays, Settled Asbestos Dust, 1994)

There are no regulated limits for asbestos in settled dust. The potential for settled dust to create unacceptable exposures to airborne asbestos, however, is recognized by both the U.S. EPA and the U.S. OSHA in their respective regulations, guidance documents, and interpretations. Asbestos is considered an inhalation hazard. Asbestos structures which are airborne in the breathing zone can be inhaled. Important exposure sources include the mining and milling of asbestos minerals, manufacture of asbestos-containing products, handling and shipping of those products, installation of ACMs, removal of ACMs, and disturbance of ACMs during operations and maintenance activities. Asbestos fibers and structures in settled dust can become airborne when the dust is disturbed and thereby pose an inhalation hazard. The resulting air concentrations can be significant. We believe one of the most important sources of exposure related to in-place ACMs is disturbance of asbestos-containing settled dust.

The literature is flush with the hazard potential from asbestos dust. (Bonsib, 1937) (Fleischer, 1946) (Harries, 1968) (Harries, 1971) (Sawyer, 1977) (Baldwin, 1982) (Keyes, 1991) (Singer, 1992) (Keyes, 1992) (Ewing, 1992) (Ewing, 1993) (Keyes, 1994) (Hatfield, 1997) (Dodson, 2006) (EPA, 1979) (Doll, 1955) (Dreesen, 1938) (Asbestosis, 1949, p. 1219) (National Safety Council, 1934-1949)

6. Bystander Exposure

"Bystander" is used in this report to mean any people who are in the vicinity of asbestos related work but not actually themselves manipulating the asbestos-containing products. These can be persons of other construction trades, laborers, vendors, delivery people, equipment operators, industrial process operators, managers, casual observers, etc. Exposure to airborne asbestos occurs to workers who repair, remove, or otherwise disturb asbestos-containing materials. Exposure also occurs to workers who clean-up asbestos debris and dust. While all of these activities are in progress, exposure to airborne fibers occurs to other people (bystanders) in the immediate vicinity and in some circumstances to people distant from the activities.

People who were not directly involved in the manufacture, use, installation, repair, and removal of asbestos-containing products can be at risk. In the repair, renovation, construction, power production and shipbuilding industries it is very common for multiple trades to be working side by side, or in an overlapping manner. This is referred to loosely as sequencing. For example, with regard to installation of asbestos-containing products, it would not be uncommon to see pipe fitters working near pipe insulators; it also would not be uncommon for white collar workers to episodically pass through this aforementioned area as a supervisor. In the course of a blue collar worker's career it would not be uncommon for him/her to be exposed to varying degrees of airborne asbestos fibers, especially during the height of asbestos use, during the 1950's, 1960's, and early 1970's. (ATSDR, 2001) (Harries, 1968) "First impressions of the problem would suggest that only those men continuously working with asbestos are at risk. In the dockyards these men would be the mattress workers, laggers, sailmakers working with asbestos cloth, asbestos sprayers, and strippers, and storeman. Experience has shown, and further consideration of the industry and processes should suggest, that many other men have been at risk." In this same 1968 study, asbestosis was discovered in other job classifications like electrical fitter, engineer, and welder. Harries "attempted to show that as an industry the Navy uses large amounts of many different products containing asbestos in varied and difficult working conditions. The work often gives rise to high dust concentrations and many people working near the different processes may be exposed to the hazard. We know that men other than those working directly with asbestos are

contracting asbestosis." (Harries, 1968) The scientific literature reveals significant exposure to bystanders. (Hillerdahl, 1999), (Harries, 1971) (Hatfield, Insulating Cement, 1999) (Hatfield, Audicote, 1998) (Selikoff, 1972) (Hatfield, US Gypsum Acoustical, 1997) (Egan, Monokote, 1970) (Fischbein, Drywall, 1979) (Keyes, Baseline, 1994) (Keyes, Re-entrainment, 1992) (Keyes, Cable Installation, 1991) (Ewing, Cable Installation, 1993) (Ewing, Take Home, 2007) (Ewing, Boiler Room, 1992) (Kilburn, 1985) (Gorman, 2004) (Lerman, 1990) (Lilienfeld, 1991) (Millette, Releasability, 1995) (Millette, Gaskets and Packing, Chapter 6, 1996) (McKinnery, 1992) (Grandjean, 1986) (Dodson, 2006) Exposure to bystanders can be as high as to people actually doing the work with ACMs (asbestos-containing materials). (Harries, 1971) (Selikoff, 1972) (Keyes, 1992) (Cross, 1971)

"The population at risk includes not only those engaged in the manufacture and use of asbestos products, but also bystanders and others limited to neighborhood or familial exposures." (Sawyer, 1977) "While most studies of asbestos and the development of human disease have focused on individuals occupationally exposed, there is an increasing body of evidence that non-occupational exposure, usually called environmental or bystander exposure, can lead to the development of asbestos-related disease." (Dodson, 2006) Grandjean and Bach state that "[i]ndirect exposure may occur at work when adjacent workers are exposed to hazards originating from fellow workers' activities. Indirect exposures of household members may occur when hazardous substances are carried home (e.g., in the clothing)." (Grandjean, 1986) According to Goldberg, "[c]oncern used to be focused on the occupational environment, but it is now recognized that asbestos fibers are widely distributed in the general environment. Persons can be exposed to asbestos in different non-occupational circumstances: living with asbestos workers, with regular exposure to soiled work clothes brought home; environmental exposure in the neighborhood of industrial sources (asbestos mines and mills, asbestos processing plants); passive exposure in buildings containing asbestos…" (Goldberg, 2005) In 1979, Selikoff comments on a previous study from 1976 stating that "[a] source of home contamination in individual exposure was postulated as resulting from dust adhering to shoes, hair, and work clothes brought home for laundering. Change rooms and company laundered coveralls were not available at this plant." This 1979 study also notes that "[t]he observation that nearly one-half of the wives examined had abnormal x-rays is consistent

with the hypothesis that the wives would have been most heavily exposed because they were responsible for the laundering of work clothes and resided in the household for the longest period of time." (Selikoff, 1979) Chen states that "[w]e report this case to emphasize the association of malignant mesothelioma with a very limited exposure to asbestos…" (Chen, 1978) According to ASTDR, "[y]ou can bring asbestos home in the dust on your hands or clothes if you work in the mining or processing of minerals that contain asbestos, in asbestos removal, or in buildings with damaged or deteriorating asbestos." (ATSDR, 2001) Edge states that "[m]alignant mesothelioma may follow relatively low and sometimes brief exposure to asbestos dust." (Edge, 1978) Hillerdahl states that "[o]rdinary vacuum cleaning is not effective in removing asbestos fibres, which can remain for years in the house and be airborne again whenever disturbed." (Hillerdahl, 1999) Regarding the resuspension of asbestos dust, the movement of a worker in a small unventilated room while wearing a laboratory coat contaminated with Marinite dust resulted in airborne asbestos concentrations ranging from 3.3 to 24.0 fibres/cm^3 (n=3). (Carter, 1970)

This theme of household or familial asbestos exposure from asbestos contaminated work clothes is recalled in several other instances. (Bianchi 2001) (Lerman, 1990) (Ferrante, 2007) (Huncharek, 1989) (EPA, 1990) (Anderson, 1976) (Newhouse, 1965) (NIOSH, 1995) (Ewing, Take Home, 2007) (Sawyer, 1977) (Revell, 2002)

7. Fiber Type and Fiber Size

Fiber Type

ATSDR states that "All forms of asbestos are hazardous, and all can cause cancer, but amphibole forms of asbestos are considered to be **somewhat** more hazardous to health than chrysotile."[1] {emphasis added} Grace experts contend that fiber type and length are extremely important with regard to potential exposure risk. In discussions about fiber type, OSHA states that "[a]fter a comprehensive review of the evidence submitted concerning the validity of the 1984 risk assessment, OSHA has determined that it will continue to rely on the earlier analysis.

The Agency believes that the studies used to derive risk estimates remain valid and reliable, and that OSHA's decision to not separate fiber types for purposes of risk analysis is neither scientifically nor regulatorily incorrect. There are at least three reasons for OSHA's decision not to separate fiber types.

1 First, OSHA believes that the evidence in the record supports similar potency for chrysotile and amphiboles with regard to lung cancer and asbestosis. The evidence submitted in support of the claim that chrysotile asbestos is less toxic than other asbestos fiber types is related primarily to mesothelioma. This evidence is unpersuasive, and it provides an insufficient basis upon which to regulate that fiber type less stringently.

2 Second, as stated in the 1986 asbestos standard, even if OSHA were to accept the premise (which it does not), that chrysotile may present a lower cancer risk than other asbestos fiber types, occupational exposure to chrysotile asbestos still presents a significant risk of disease at the revised PEL (See 51 FR 22649, 22652). In particular, asbestosis, the disabling and often fatal fibrosis of the deep portions of the lung, is caused by exposure to all types of asbestos. The evidence on this is strong and no new information has been presented to contradict this. As stated above, OSHA estimated asbestosis risks at 0.2 f/cc exposures as an unacceptably high 5 cases per 1000 workers. Thus, asbestosis risks alone justify the regulation for chrysotile.

3 Third, the record shows that employees are likely to be exposed to mixed fiber types at most construction and shipyard industry worksites most of the time. Assigning a higher PEL to chrysotile would present the Agency and employers with analytical difficulties in separately monitoring exposures to different fiber types. Thus, regulating different fiber types at differing levels, would require more monitoring all the time and would produce limited benefits (51 FR 22682)." (OSHA, 1994)

In a letter from the WHO, it is clearly stated that "all types of asbestos cause asbestosis, mesothelioma, and lung cancer." (WHO, 2006) According to Dr. Richard Lemen, "We are at a point in the history of asbestos usage where chrysotile is the predominant type asbestos produced

and consumed in the world today; it constituted about 98.5% of US consumption in 1992…A review of 92 consecutive cases of mesothelioma found that even while only 28.3% of the asbestos fiber type in the lung was chrysotile, it was the major fiber type identified in the mesothelial tissue itself. These findings further suggest that lung burden analysis for determining fiber type in mesothelioma etiology may not be appropriate and that determining predominate fiber type in the mesothelial tissue is the more rational determinant." (Lemen, 2001) Nicholson concludes, "[f]rom studies in the United States and Great Britain, chrysotile has been shown to increase the risk of lung cancer and to produce mesothelioma in exposed workers." (Nicholson, 2001) Other literature express this notion. (Smith, 1996) (Beddington, 2001) (Stayner, 1996) (Kahansly, 2001) (Kanarek, 2011)

Fiber Size

According to Dodson and his research, the regulated fiber size (≥ 5μm) "selection criteria were based on 'practicality and theoretical considerations' rather than having a target of a 'more toxic' population of fibers." (Dodson, 2006) According to Sawyer and his research, the "…counting of only those fibers 5μm or longer is inappropriate. Airborne fiber sizes range from hundreds of microns to fibrils of submicron dimensions, and the size distribution of asbestos particles in human tissues studied by electron microscopy is in most part less than 5 μm." (Sawyer, 1977) In a 2001 study, researchers conducted fiber burden analysis in a series of individuals with mesothelioma who were 50 yr or less of age at time of diagnosis. They concluded that "[s]horter fibres were more abundant than longer fibres, and high concentrations of all fibre lengths tended to occur together." (McDonald, 2001) Dodson agrees that "…inhaled asbestos fibers cause asbestos-related disease and most frequently consist of a mixture of asbestos types and sizes." (Dodson, 2006) According to Suzuki et al., the majority of the fibers in the lung and the mesothelial tumor tissue were less than 5μm in length. (Suzuki, 2002) Suzuki later states "…that contrary to the Stanton hypothesis, short, thin, asbestos fibers appear to contribute to the causation of human malignant mesothelioma." (Suzuki, 2005) Dodson states that "[t]he fact that short fibers (< 5μm) have been shown to produce toxic effects in macrophages in vitro and to be fibrogenic tumorigenic in animals in vitro, and that they reach the site of mesothelioma

development support the inappropriateness of discounting their role in asbestos-related disease as has been done…" (Dodson, 2006)

8. Asbestos-containing Thermal System Insulation (TSI)

"Of the asbestos-containing products which are widely used by these men, magnesia block insulation was and remains perhaps the most important. This usually contains approximately 15 percent asbestos. While asbestos cement has a varying asbestos content depending upon its manufacturer, it also generally has 15-20 percent or less of asbestos…We may conclude that asbestosis and its complications are significant hazards among insulation workers in the United States at this time." (Selikoff, 1965) In the insulating trades, "asbestos content of materials in use ranges from 10% to almost 100%. Asbestos substitutes are gaining in use as regulations over the use of asbestos become increasingly restrictive." (Levin, 1978) "Asbestos, as used by the insulating industry, consists mainly of chrysotile, a magnesium silicate mines principally in Canada, and amosite, an iron magnesium silicate mines in South Africa. Since World War II, amosite has been the most widely used fiber in insulating materials. However…the use of chrysotile has increased to where the two are presently in about the same number of insulating products. Asbestos is usually combined with a filler material such as calcium silicate, in the amounts indicated in Table I, and pre-formed into various shapes, magnesium silicate was often used, but except for some in warehouse stock and a few special orders almost all the new silicate-containing insulating materials are made of calcium silicate." (Balzer, 1968)

TABLE I

Type and Per Cent of Asbestos in Insulating Products Used in the San Francisco Bay Area

TYPE OF ASBESTOS	% BY WEIGHT	NO. PRODUCTS
Chrysotile	10-15	2
Chrysotile	85-100	3
Amosite-chrysotile	10-15	3
Amosite	10-15	3
Amosite	95-100	3

In another report from Balzer in 1968, "Our analysis of the insulating worker's environment indicates that they are predominately working with calcium silicate and magnesium carbonate insulating material containing asbestos fibers, fibrous glass materials, plastics, foam glass, cork, and adhesives." Regarding the calcium silicate and magnesium carbonate asbestos-containing insulating material: 100% - Amosite blankets; 95% - Amosite-5% filler; 10-15% - Mixed amosite and chrysotile-85% magnesia; 10-15% - Amosite-85% calcium silicates; 10-15% - Mixed amosite and chrysotile 85% calcined diatomaceous silica; 100% - Chrysotile asbestos shorts for finishing (mud); 50% - Asbestos shorts and 50% cement for finishing (mud). In this same study Balzer reports the percentage and type of asbestos in insulating products in current use:

TABLE IV
Percentage and Type of Asbestos in Insulating Products in Current Use

Type of Asbestos	Percent by Weight	Number of Products
Amosite	10–15%	3
Amosite	95–100	3
Amosite-Chrysotile	10–15	3
Chrysotile	10–15	2
Chrysotile	85–100	3

(Balzer, Environment, 1968)

Fleischer highlights that "AN INDUSTRIAL (sic) health inspection of an important U. S. Navy Contract Yard indicated that dustiness from miscellaneous pipe covering operations was considerable and that a few of the employees had what appeared to be asbestosis." (Fleischer, 1946) Levine further details by stating that "[e]xposures in the insulation trades vary widely, but they include the highest occupational exposures and control is difficult." (Levine, 1978) In a steam-electric generating plant in 1975, Fontaine states "[m]ost of the insulation was preformed pipes and blocks of hydrous calcium silicate insulation reinforced with asbestos fibers." (Fontaine, 1975) Fleischer observed that "[i]n textile plants workers usually continue at specific jobs with fairly constant dust exposures for some years, whereas the pipe coverer may rotate between shop and ship and from small to large ship compartments with a wide variation in dust exposure." (Fleischer, 1946) Harries explains that the "…highest dust concentrations occur during

removal of old lagging material. There are other minor processes involving the fitting or removal of asbestos materials some of which produce dust…cleaning with wire brushes, pipes and glands previously lagged with asbestos. Most of these procedures are carried out intermittingly by men who are not considered to be 'asbestos workers'." (Harries, 1968) Browne describes the removal methods for TSI, "[t]he classical method of removing lagging when repairs needed to be done was to go at it with hammer, chisel and wire brush, without damping it, with the consequent production of horrifically high asbestos fiber counts which might persist for as long as a week." In this same Browne report, "[a]sbestos fiber counts in a power station after the old-style method of removing lagging" produced levels ranging from 2.0 to 492.0 f/cm^3 (n=16), with the highest levels seen around the turbine control panel. (Browne, 1971) According to Harries, "…very large numbers of men have been exposed to asbestos dust by working with or near other men who were applying or removing asbestos materials, or because they themselves were disturbing asbestos debris and creating their own local dust clouds." (Harries, Asbestos Dust, 1971) In a previous Harries study, "[a]sbestos dust is liberated during manipulation, and especially during vigorous tearing down of most of the asbestos materials used in the dockyard. The main problem is to contain the dust and prevent dispersal throughout the ship." (Harries, 1968)

In the Harries 1971 study, he reports the level of airborne asbestos in the breathing zone and general atmosphere during pipe and machinery insulation removal and installation. During the removal of pipe and machinery insulation in boiler rooms, engine rooms and brick stowage space, the general atmosphere levels ranged from 0.04 to 3,021.0 f/cm^3 with averages of 171.0, 88.0 and 257 f/cm^3, respectively (n=211). During the removal of pipe and machinery insulation in boiler rooms, engine rooms and brick stowage, the breathing zone levels ranged from 2.0 to 490.0 f/cm^3 with averages of 97.0 and 91.0 f/cm^3, respectively (n=45). During the installation of pipe and machinery insulation in boiler rooms, engine rooms and an accumulator room, the general atmosphere levels ranged from 0.1 to 61.0 f/cm^3 with averages of 22.4, 2.1 and 16.5 f/cm^3, respectively (n=50). During the installation of pipe and machinery insulation in boiler rooms,

engine rooms and an accumulator room, breathing zone levels ranged from 0.04 to 68.0 f/cm^3 with averages of 16.8, 7.3 and 9.6 f/cm^3, respectively (n=47). Several miscellaneous activities are associated with pipe and machinery insulation. For "Mixing asbestos 'plastic mix' with water in bucket", general atmosphere levels ranged from 53.0 to 377.4 f/cm^3, with an average of 167.0 f/cm^3 (n=3); breathing zone levels ranged from 24.0 to 579.0 f/cm^3 with an average of 256.0 f/cm^3 (n=12). For "Sawing calcium silicate sections", general atmosphere levels ranged from 0.7 to 158.0 f/cm^3, with an average of 68.0 f/cm^3 (n=7); breathing zone levels ranged from 7.0 to 152.0 f/cm^3, with an average of 55.0 f/cm^3 (n=11). For "Removing calcium silicates sections from a box", general atmosphere levels ranged from 2.0 to 78.0 f/cm^3, with an average of 30.0 f/cm^3 (n=7); breathing zone levels ranged from 16.0 to 136.0 f/cm^3, with an average of 52.0 f/cm^3 (n=10). For "Fitting calcium silicate section to pipe", general atmosphere levels ranged from 0.0 to 23.0 f/cm^3, with an average of 4.1 f/cm^3 (n=9); breathing zone levels ranged from 1.0 to 129.0 f/cm^3, with an average of 43.0 f/cm^3 (n=20). For "Cleaning calcium silicate debris", general atmosphere levels ranged from 32.0 to 372.0 f/cm^3, with an average of 134.0 f/cm^3 (n=9); breathing zone levels ranged from 90.0 to 277.0 f/cm^3, with an average of 155.0 f/cm^3 (n=7). For "Fitting cloth over lagged pipe", breathing zone levels ranged from 0.3 to 43.0 f/cm^3, with an average of 22.0 f/cm^3 (n=7). For "Sweeping and bagging amosite debris" general atmosphere levels ranged from 76.3 to 1,191.0 f/cm^3, with an average of 564 f/cm^3 (n=10). Harries concludes that "precautions are…to protect all workers whether they work directly with asbestos or not [including]...Management Visitors, those who pay short supervisory visits to places where asbestos work is proceeding." (Harries, Asbestos Dust, 1971)

Levine notes that the "[h]ighest concentrations encountered by insulation workers have occurred during "rip-out" or removal of old asbestos insulations…removal of 100% asbestos lagging, and the subsequent cleanup were said to average…62-159 fibers per milliliter, and 353 fibers per

Case 2:13-cv-01456-CNC Filed 09/15/14 Page 25 of 108 Document 71

milliliter, respectively….Nearby workers may be exposed to elevated levels of asbestos as a result of the activities of insulators…" (Levine, 1978) Concerning the work environment in a shipyard, Gorman states that "…a lagger recounted how his job frequently put other tradesmen in danger: You used to saw the stuff. Well the, teased-up stuff and the dust just a' floated. It floated round and everybody got their share." (Gorman, 2004) Considerable dust measurements were collected by the US Navy while workers were stripping old amosite pipe insulation. So much so that "in view of the high dust counts obtained…that work of this nature be scheduled to lessen [the exposure] to incidental trades when possible." (US Navy, 1964) In a Balzer study, an average fiber concentration of airborne asbestos in the general vicinity of pipe insulation work was reported to be 8.5 f/cc during prefabrication, 6.4 f/cc during application, 2.7 f/cc during finishing, 8.9 f/cc during tear out, and 2.6 f/cc during mixing. (Balzer, Industrial Hygiene, 1968) In a study conducted by the US Navy during the application of pipe insulation (10% amosite), a dust count of 1.8 mppcf was reported; in an engine room the general atmosphere during the application of insulation was 4.3 mppcf; the general atmosphere near installation of lagging on piping was 7.8 mppcf; sawing insulation blocks for catapult receivers was 6.1 mppcf; installing insulation blocks was 5.0 mppcf; the general atmosphere where blocks are being installed was 3.3 mppcf; the breathing zone of pipe coverers installing insulation block was 6.2 mppcf; and the sawing of insulation blocks produced a dust level of 6.1 mppcf. A sample taken near insulation "ripout" was reported to be 17.0 mppcf; removing steam pipe insulation was 20.0 mppcf; and after "ripout" had occurred was 12.0 mppcf. Because of the dust samples reported, the Navy states that "[t]hese samples indicate the possibility of excessive exposure to asbestos dust." (US Navy, 1961) According to a NIOSH study, "[c]utting calcium silicate, block, pipe #1" in a powerhouse open space using a table and hand saw was reported to be 1.2 fibers/ml; "[c]utting calcium silicate, block & pipe #2" in an industrial building in good ventilation was reported to be 4.1 fibers/ml; "[c]utting of calcium silicate block & pipe" in an apartment house boiler room with no ventilation was reported to be 11.5 fibers/ml in the breathing zone; "[c]utting of calcium silicate block & pipe #4" with limited ventilation was reported to be 9.4 fibers/ml, with an area sample reported to be 1.6 fibers/ml (3.0-4.0 feet away). (NIOSH, 1972)

A 1992 study by Ewing investigated exposure to airborne asbestos during disturbance of thermal

system insulation on a boiler. A section of boiler insulation, approximately 1.5 square feet, was removed. Two personal air samples were analyzed by transmission electron microscopy (TEM), with results of 305.0 asbestos structures per cubic centimeter (s/cc) and 147.0 s/cc. Area samples, also analyzed by TEM, ranged from 2.5 to 115 s/cc (n=6). After the removal period was completed, or during the "die-down" period, area samples ranged from 6.1 to 12.0 s/cc (n=5). General cleaning activities were also investigated, and the cleaning portion of the study was conducted prior to the maintenance activity. Area samples were analyzed by TEM, and results ranged from 6.5 to 106.0 s/cc (n=6). A personal air sample analyzed during this activity resulted in an asbestos level of 76.0 s/cc. (Ewing, Boiler, 1992)

In a 1970 study by the US Navy, "[a]irborne asbestos dust samples were collected aboard several ships of various sizes, ranging from destroyers to aircraft carriers, and in the shop complex." Samples were analyzed and reported in mppcf. "Asbestos cloth; cutting, fitting, glueing (sic), and installing" resulted in a range from 2.8 to 5.7 mppcf, with an average of 4.3 mppcf. "Magnesia block; cutting, installing" resulted in a range from 3.5 to 40.5 mppcf, with an average of 16.7 mppcf. "Magnesia block…(cutting, glueing(sic))" resulted in a range from 1.1 to 1.3 mppcf, with an average of 1.2 mppcf. "Amosite…(cutting, fitting, applying)" resulted in a range from 0.4 to 4.7 mppcf, with an average of 2.4 mppcf. "Asbestos cloth…(cutting, fitting, sewing)" resulted in a range from 0.1 to 4.0 mppcf, with an average of 0.2 mppcf. "Amosite: Installation" resulted in a range from 2.6 to 8.9 mppcf, with an average of 5.6 mppcf. "Magnesia block: Cutting & installing" resulted in a range from 2.4 to 13.3 mppcf, with an average of 6.1 mppcf. "Asbestos cloth: cutting, fitting, glueing (sic)" resulted in a range from 3.1 to 4.6 mppcf, with an average of 3.6 mppcf. "Asbestos cement: Mixing" resulted in a range from 11.5 to 82.8 mppcf, with an average of 47.5 mppcf. The study concludes, "[i]n general, workers handling, sawing, cutting or ripping-out asbestos materials produce considerable amounts of very fine asbestos fibers and particles in their breathing zone." (Mangold, 1970)

In the work environment, asbestos-related risk and disease associated with the manipulation of thermal system insulation above background levels can be seen in the literature. (Finkelstein, 2004) (Selikoff, 1965) (Fletcher, 1971) (ASTDR, Asbestos and Your Health, 2006) (OSHA FR,

1994) (Dodson, 2006) (Balzer, 1972) (Cooper, 1970) (Army, 1992) (Marr, 1964) (Merewether, 1930) (Cross, 1971) (Balzer, Environment, 1968) (Divine, 1999) (Lewis, 2000) (Jones, 1981)

9. Asbestos-containing Gaskets

"The term 'gasket' is a general term for a number of sealing materials, including sheet gaskets and packing. Sheet gasket materials are used to seal pipe joint connections and prevent leakage of fluids between the solid surfaces of the pipe flanges…Gaskets, often consisting of more than 70% chrysotile asbestos, are used against alkaline, neutral or weak acid solutions. Crocidolite (blue asbestos) containing gaskets have been used against harsher acid solution. Sheet gaskets are composed of chrysotile asbestos compressed into a sheet with styrene butadiene rubber or other binder. Other organic binder used in making asbestos gaskets include natural rubber, buna-S and buna-N synthetic rubbers, or neoprene. Sheet gasket material is sold in a farm that is precut to fit a certain size flange or may be sold in sheets from which gaskets are cut to fit a particular flange assembly. In their original state, gaskets which are composed of asbestos in an organic binder are not considered friable. However, gasket material after service may be friable." (Millette, Mount, Hays, 1996) "…gaskets normally contained 70 percent to 80 percent chrysotile asbestos by weight. In some cases crocidolite asbestos was used for special applications, that is, sealing □ flanges in acid lines. The remaining non-asbestos component of the gasket was usually constructed of synthetic rubber material that consisted of either neoprene, styrene butadiene rubber (SBR), or a nitrile polymer." (Longo, 2002) In a 1992 asbestos exposure study, the gasket material was found to have an asbestos content of 50-60% chrysotile asbestos. (McKinnery, 1992) In a Mangold study, he reports that a typical gasket used in the 1940's to the 1970's were "about 70% chrysotile asbestos." (Mangold, 2006) Cheng reports typical gasket material in the oil and chemical industries to be "Sheet gaskets, which are typically 1/16 or 1/8 inch thick compressed asbestos sheets (containing at least 70% chrysotile asbestos)…Spiral wound gaskets, which consist of asbestos filler material…Metal-jacketed gaskets, which consist of compresses asbestos filler…" (Cheng, 1991) "Asbestos is the primary constituent for making compressed sheet gaskets (varying upwards from 75 percent by weight depending on the application)." (ICF, 1989)

Studies addressing airborne asbestos exposures produced by removal of sheet gaskets have been published by Millette, Mount, and Hays. Sheet gaskets are composed of asbestos compressed with binders, such as natural or synthetic rubbers. “In their original state, asbestos-containing sheet gasket materials which are composed of asbestos in an organic binder are not considered friable. However, gasket material after service may be dry and friable.” Millette, Mount, and Hays reported asbestos concentrations when removing sheet gaskets (“Garlock” brand) by various combinations of hand scrapping and power wire brushing. Samples were collected in this study: 1) before and during the removal of asbestos sheet gasket material and wire-brushing of the pipe flange, and 2) during the cleanup of asbestos dust and debris following a cutting of a gasket material with a band saw. These results were from analyses of the samples by phase contrast microscopy (PCM), NIOSH method 7400. Some of the samples were also analyzed by TEM using the International Standards Organization (ISO) direct preparation method. The sheet gaskets in the study were removed from a steam valve that had been in service on a ship. During sampling event 1, PCM analysis reported asbestos levels during “hand scraping”, “power wire brushing”, “hand scraping and power wire brushing”, and “broom sweeping of area after removal” at 0.14, 6.8, 2.1, and 5.5 f/cc, respectively. For TEM analysis, these same tasks reported levels at 3.9, 62.0, 20.0 and 44.0 s/cc, respectively. During sampling event 2, PCM analysis reported asbestos levels during “cutting of the gasket”, “background before sweeping”, and “sweeping of dust and debris” at 11.0, 0.13, and 1.7 f/cc, respectively. For TEM analysis, these same tasks reported levels at 30.0, 0.37, and 5.9 s/cc, respectively. (Millette, 1995)

Longo, Egeland, Hatfield, and Newton reported airborne concentrations during removal of sheet gaskets from a variety of small and large valve and flange assemblies. These had been in service at a power house. The gasket material used in this study contained 65% to 85% asbestos. Removal was done using combinations of hand scraping, hand wire brushing, and power wire brushing. All removal was done dry. All airborne concentrations were reported in fibers per cubic centimeter, and only fibers greater than 5 micrometers in length were included in the reported concentrations. **For small flange removal**, using a scraping and hand wire brush method, personal “worker” samples analyzed by PCM ranged from 1.5 to 10.1 f/cc (n=14), with a

Case 2:13-cv-01456-CNC Filed 09/15/14 Page 29 of 108 Document 71

calculated 8-hr TWA of 1.5 f/cc, and personal "worker" samples analyzed by TEM ranged from 29.9 to 144.2 f/cc (n=14). Personal "assistant" samples analyzed by PCM ranged from 1.2 to 4.2 f/cc (n=14), with a calculated 8-hr TWA of 1.0 f/cc, and personal "assistant" samples analyzed by TEM ranged from 2.2 to 29.5 f/cc. **For large flange removal**, using a scraping and hand wire brush method, personal "worker" samples analyzed by PCM ranged from 9.3 to 24.0 f/cc (n=10), with a calculated 8-hr TWA of 3.6 f/cc, and personal "worker" samples analyzed by TEM ranged from 199.6 to 842.7 f/cc (n=14). Personal "assistant" samples analyzed by PCM ranged from 5.2 to 15.7 f/cc (n=10), with a calculated 8-hr TWA of 2.0 f/cc, and personal "assistant" samples analyzed by TEM ranged from 13.6 to 101.0 f/cc. "Area" asbestos levels for this activity were reported by PCM at a range of 2.1 to 8.4 f/cc (n=24), and by TEM at a range of 3.3 to 108.8 f/cc (n=24). **For large flange removal**, using a power wire brush method personal, "worker" samples analyzed by PCM ranged from 14.9 to 31.0 f/cc (n=7), with a calculated 8-hr TWA of 2.3 f/cc, and personal "worker" samples analyzed by TEM ranged from 877.1 to 1,636.1 f/cc (n=7). Personal "assistant" samples analyzed by PCM ranged from 12.8 to 21.2 f/cc (n=8), with a calculated 8-hr TWA of 2.0 f/cc, and personal "assistant" samples analyzed by TEM ranged from 60.4 to 364.4 f/cc (n=8). "Area" asbestos levels for this activity were reported by PCM at a range of 7.6 to 15.7 f/cc (n=16), and by TEM at a range of 56.9 to 801.9 f/cc (n=16). {emphasis added}(Longo et al., 2002)

McKinnery and Moore reported airborne concentrations for the removal and installation of asbestos-containing valve gaskets. Work practices and tools used conformed to those used by maintenance personnel. Both personal and area samples were collected. During the **removal** of the gaskets, personal samples analyzed by PCM ranged from 0.05 to 0.44 f/cc (n=23), with a geometric mean of 0.16 f/cc, and personal samples analyzed by TEM ranged from 0.86 to 18.45 s/cc (n=26), with a geometric mean of 2.73 s/cc. During the removal of the gaskets, area samples collected at various points within containment and analyzed by PCM ranged from 0.00 to 0.59 f/cc (n=49), while area samples analyzed by TEM ranged from 0.29 to 28.22 s/cc (n=42). During the **installation** of the gaskets, personal samples analyzed by PCM ranged from 0.13 to 0.29 f/cc (n=12), with a geometric mean of 1.28 f/cc, and personal samples analyzed by TEM ranged from 0.4 to 74.32 s/cc (n=12) with a geometric mean of 3.40 s/cc. During the installation

of the gaskets, area samples collected at various points within containment and analyzed by PCM ranged from 0.11 f/cc to 0.35 f/cc (n=24), while area samples analyzed by TEM ranged from 0.85 s/cc to 5.53 s/cc (n=24). (McKinnery et al., 1992)

In a Boelter study, in-place gaskets were manipulated with various actions on machinery in relation to the industrial and maritime industries. Industrial "flat blade scraping" resulted in personal asbestos levels of 0.028 and 0.035 f/cc; "room air" asbestos levels were reported to range from 0.020 to 0.034 f/cc (n=8). Industrial "hand wire brushing" resulted in personal asbestos levels of 0.005 and 0.007 f/cc; "room air" asbestos levels were reported to range from 0.005 to 0.010 f/cc (n=8). Industrial "power wire brushing" resulted in personal asbestos levels of 0.021 and 0.023 f/cc; "room air" asbestos levels were reported to range from 0.015 to 0.020 f/cc (n=8). Industrial "making gaskets with a ball peen hammer" resulted in personal asbestos levels of 0.038 and 0.052 f/cc; "room air" asbestos levels were reported to range from 0.030 to 0.048 f/cc (n=8). Maritime "flat blade scraping" resulted in personal asbestos levels of 0.014 and 0.019 f/cc; "room air" asbestos levels were reported to range from 0.014 to 0.020 f/cc (n=8). Maritime "hand wire brushing" resulted in personal asbestos levels of 0.0 and 0.004 f/cc; "room air" asbestos levels were reported to range from 0.001 to 0.004 f/cc (n=8). Maritime "power wire brushing" resulted in personal asbestos levels of 0.008 and 0.010 f/cc; "room air" asbestos levels were reported to range from 0.008 to 0.014 f/cc (n=8). Maritime "making gaskets with a ball-peen hammer" resulted in personal asbestos levels of 0.022 and 0.029 f/cc; "room air" asbestos levels were reported to range from 0.017 to 0.025 f/cc (n=8). (Boelter, 2002)

According to Cheng, dry scraping/brushing two gaskets during a valve replacement resulted in an airborne asbestos concentration of 0.11 fibers/cc; dry scraping/brushing one gasket for a pump resulted in an airborne asbestos concentration of 0.19 fibers/cc; dry scraping/brushing two flange gasket resulted in an airborne asbestos concentration of 0.33 fibers/cc; dry power sanding two pipe flange gaskets resulted in an airborne asbestos concentration of 1.4 fibers/cc; wet scraping/brushing one gasket for a pump resulted in an airborne asbestos concentration of <0.06 fibers/cc; and wet brushing two pipe flange gaskets resulted in an airborne asbestos concentration of <0.06 fibers/cc. (Cheng, 1991)

The literature is replete with worker and/or bystander asbestos exposure above background levels through the removal, installation and cleanup of asbestos-containing gaskets. (Anderson, 1982) (Liukonen, 1978) (Silverhorne, 1973) (Hatfield, 2001) (Hatfield & Bennett, 1985) (Hatfield, Spiral Wound, 2000) (Jones, 1981) (Spence, 1998) (Longo, 2006) (Boelter, 2002) (Mangold, 2006) (Millette, Mount, Hays) (Fowler, 2000) (Longo, 2001) (Mount, 1988) (Boelter, 2011)

10. Asbestos-containing Packing

"Packing is often found inside valve systems and has been used on boiler and furnace doors." According to the U.S. Environmental Protection Agency (EPA) asbestos packing means an asbestos-containing product intended for use as a mechanical seal in circumstances involving rotary, reciprocating and helical motions, and which are intending to restrict fluid or gas leakage between moving and stationary surfaces." (Millette, Mount, Hays, 1996) "Examples where these packings have traditionally been used are in pumps, valves, compressors, mixers, and hydraulic (piston-type) cylinders." (ICF, 1989) In a 1992 asbestos exposure study, the packing material was found to have an asbestos content of 30-50% chrysotile asbestos. (McKinnery, 1992) In a Millette study, with regard to used packing that was removed from a valve in an abandoned steam power plant, "microscopic analysis showed it to be approximately 85 percent chrysotile…" (Millette, 1993) "The braided variety of packings are the most prevalent and all of the well-known packing manufacturers produce them by similar methods of construction. Asbestos packing are braided of strong, highest quality pure asbestos yarn." Grade standards of asbestos yarns used in asbestos-containing packings can range from 75% to 100% asbestos content. (ICF, 1989)

A Millette, Mount, and Hays document published air concentrations from the literature for asbestos-containing packing removal ranging from 0.05 to 1.01 f/cc (PCM) and from 0.52 to 19.57 s/cc (TEM). Installation of packing ranges from 0.04 to 0.52 f/cc (PCM) and 0.07 to 4.05 s/cc. This article notes another published study which gives packing removal air concentrations ranging from 0.2 to 1.3 f/cc (PCM) and from 1.5 to 4.2 s/cc (TEM). The article also reports a packing removal study conducted by the authors in which the air concentration by PCM was 0.14

f/cc, and the air concentrations by TEM ranged from 0.4 to 1.4 f/cc for asbestos fibers of all sizes. (Millette, Chapter 6, 1996)

McKinnery and Moore reported airborne concentrations for the removal and installation of asbestos-containing packing materials. Work practices and tools used conformed to those used by maintenance personnel. Both personal and area samples were collected. During the removal of the packing materials, personal samples collected and analyzed by PCM ranged from 0.05 to 1.01 f/cc (n=21), while personal samples analyzed by TEM ranged from 0.52 to 19.57 s/cc (n=7). During the removal of the packing materials, area samples collected at various points in containment and analyzed by PCM ranged from 0.04 to 0.60 f/cc (n=42), while area samples analyzed by TEM ranged from 0.39 to 18.86 s/cc (n=7). During the installation of the packing material, personal samples taken and analyzed by PCM ranged from 0.04 to 0.52 f/cc (n=18), and personal samples analyzed by TEM ranged from 0.07 to 4.05 s/cc (n=6). During the installation of packing, area samples analyzed by PCM ranged from 0.03 to 0.75 f/cc (n=36), and the area samples analyzed by TEM ranged from 0.03 to 10.68 s/cc (n=6). (McKinnery, 1992)

Millette and Mount reported airborne concentrations during the removal of asbestos-containing valve packing in an unused steam power plant. The packing was removed by a retired steam plant worker using tools and procedures typical for the industry. Personal samples were collected from the individual doing the removal as well as from an observer. Area samples were also collected during the removal. Personal samples collected from the individual removing the packing and analyzed by PCM ranged from 0.2 to 1.3 f/cc (n=5), while TEM analysis ranged from 1.5 to 4.2 f/cc (n=4). Personal samples collected from the observer and analyzed by PCM ranged from 0.1 to 0.9 f/cc (n=6). Area samples collected during the removal and analyzed by PCM ranged from 0.06 to 0.4 f/cc (n=5). The authors concluded that "[t]he results of these test suggest that asbestos packing material, although not identified as friable ACM, should be considered as such during packing removal activities. If possible, the packing should be wetted with water or oil before it is cut and torn with packing tools such as hooks during the procedures for removing old packing." (Millette, 1993)

Other studies reveal asbestos exposure to workers and bystanders above background through the removal, installation and cleanup of asbestos-containing gaskets. (Mount, 1988) (Boelter, 2002) (Spence, 1998)

11. Asbestos-containing Friction Products

"Asbestos has-been used in brake linings and other friction products since the turn of the century, when metals, leather, and wood no longer were adequate…The predominant type of asbestos used in brake linings is chrysotile, a hydrated magnesium silicate…Passenger car and light truck drum brake linings, called segments, usually contain from 30 to 70 percent by weight of asbestos." (ASME, 1987) "The composition of automotive brake linings includes chrysotile asbestos fibre which comprises about 50% of the friction material." (Rohl, 1977) "Brake linings pose a potential hazard for asbestos exposure because they contain 33-73% asbestos." (Lorimer, 1976) "Commercial friction materials used in the United States for braking passenger cars and trucks contain an average composition of 50 percent chrysotile by weight." (Castleman, 1975) "Brake lining materials contain 40-60 per cent of asbestos." (Hickish, 1970) For disc brake pads for light/medium vehicles, "Currently, asbestos only comprises 15 percent of the OEM for disc brake pads; the balance of 85% is held by semi-metallics." (ICF, 1989) {OEM=original equipment market} "Clutch facings are friction materials attached to both sides of the steel disc in the clutch mechanism of manual-transmission vehicles. Two metal pressure plates flanking the disc are pressed against the clutch facings by springs when the clutch is engaged. This pressure keeps the gears of the vehicle in position by means of a metal component that extends between the disc and the gears…Asbestos–based molded clutch facings currently produced contain approximately 0.26 lbs. of asbestos fiber per piece." (ICF, 1989)

According to a 1986 EPA document, "Millions of asbestos fibers can be released during brake pad and clutch servicing…Asbestos released into the air lingers around a garage long after a brake job is done and can be breathed in by everyone inside a garage, including customers."(EPA, 1986) Concerns about exposure to asbestos-containing dust from automotive maintenance and repair work can be found in the other literature. (Sheehy, 1987) (Huncharek, 1989) According to a

1987 study discussing the feasibility of asbestos in automobiles and trucks, authored by the American Society of Mechanical Engineers for the EPA, "[s]uitable non-asbestos materials are not available for all of these applications, and industry-wide substitution of non-asbestos materials in all existing brake designs would require considerable development. It is unrealistic to assume that all automakers will redesign all passenger car and truck braking systems around disc brakes in order to utilize semimetallic materials… Adequate non-asbestos friction material formulations presently are not available for all vehicle systems. However, at the present rate of technical progress, most new passenger cars could be equipped with totally non-asbestos frictional systems by 1991, and most light trucks and heavy trucks with S-cam brakes, by 1992." (ASME, 1987)

In a review by Lemen, it was reported that "chrysotile asbestos was found in all dust samples taken from car brake drums, with 2-15% in each sample in both fiber and fibril forms, with average concentrations from blowing the dust of 16 fibers/ml of air…" with measurable concentrations found 75 feet away. In Lemen's review, it is noted that "fiber concentrations of 3.8 fibers/ml among New York brake repair workers" were found. Furthermore, "[g]rinding of the linings produced the most asbestos fiber release, some as high as 125 fibers/cm^3…" Lemen concludes, "[a] review of the published peer reviewed literature reveals at least 165 cases of mesothelioma in end-product users [mechanics] of friction products…and that the results of the exposure studies, experimental studies, case reports, and findings from the equivocal epidemiological studies by no means exonerate the brake mechanic from being susceptible to a causal relationship between asbestos exposure and mesothelioma." (Lemen, 2004)

In a Millette study dealing with asbestos-containing brake shoes and brake disc pads manufactured by Ford, during the sanding of brake shoes, asbestos fiber levels were 2.2 fibers/cc (PCM), 54.0 structures per cubic centimeter (s/cc) (> 5µm, TEM); during the sweeping of dust and debris; asbestos fiber levels were 1.7 fibers/cc (PCM), 12.0 s/cc (> 5µm, TEM); during filing of grooves, asbestos fiber levels were 0.3 fibers/cc (PCM), 6.7 s/cc (> 5µm, TEM); during the making of grooves in the disc pad for two minutes with a power grinder, asbestos fiber levels

Case 2:13-cv-01456-CNC Filed 09/15/14 Page 35 of 108 Document 71

were 8.5 fibers/cc (PCM), 231.0 s/cc (> 5μm, TEM). Millette further concludes that "[s]anding an asbestos-containing brake shoe friction product with a coarse sandpaper released high levels of asbestos fibers in the breathing zone of the sander. Sweeping the asbestos-containing dust and debris following sanding can release significant levels of asbestos fibers into the air (over 1 f/cc). Filing grooves into a brake disc pad also releases asbestos fibers into the air in the vicinity of the filer, but at a lower level than sanding. Using a power muffler grinder to cut the grooves in an asbestos-containing brake disc pad causes high levels of asbestos to be released." (Millette, 1996) Rohl states, "[t]he composition of automotive brake linings includes chrysotile asbestos fibre which comprises about 50% of the friction material." In this paper, exposure ranges and means, reported in f/ml (PCM), from friction products during automotive brake repair include blowing dust from brake drums at a distance from 1 – 1.5 meters (m), in which the range was 6.6 to 24.9 f/ml with an average of 15.0 f/ml (n=4); at a distance from 1.5 – 3 m, in which the range was 2.0 to 4.2 f/ml, with an average of 3.3 f/ml (n=3); and at a distance from 3 – 6 m, in which the range was 0.3 to 4.8 f/ml with an average of 1.6 f/ml (n=2). Background samples collected 5 minutes after air jet blowing at a distance of 3.6 – 16 m, revealed a range from 0.1 f/ml to 0.2 f/ml with an average of 0.2 f/ml (n=2). Background samples collected 7-14 minutes after "air jet blowing" at a distance of 19.6 – 22.6 m, revealed an average of 0.1 f/ml (n=2). During truck brake repair, "renewing used linings by grinding" at a distance of 1 – 1.5 m, revealed a range of 1.7 to 7.0 f/ml with an average of 4.8 f/ml (n=10). Background samples taken during grinding used linings at a distance of 3.3 m, the range was 1.2 to 1.7 f/ml with an average of 1.5 f/ml (n=2); at a distance of 8.3 m, the range was 0.6 to 1.0 f/ml with an average of 0.8 f/ml (n=2); and at a distance of 20 m, the level was 0.2 f/ml. Samples collected during bevelling new linings revealed a range from 23.7 to 72.0 f/ml, with an average of 37.3 f/ml (n=4). At a distance 2.4 m away from bevelling new linings, a level of 0.6 f/ml is reported; at a distance of 3.4 m away, a range from 0.3 – 0.5 f/ml and an average of 0.4 (n=2) is reported; and at a distance of 9.1 m away, a level of 0.3 f/ml is reported. (Rohl, 1977)

In a review to the EPA titled "Asbestos Dust Control in Brake Maintenance", exposure levels, reported in f/cc (PCM), from working with asbestos-containing brake products are reported. The use of a compressed air gun for several studies resulted in a range of 0.14 to 2.69 f/cc with a

TWA of 0.03 f/cc and an average peak level of 0.71 f/cc; a range of 0.91 to 15.0 f/cc with a TWA of 0.13 f/cc and an average peak level of 4.87 f/cc; a range of 6.6 to 29.8 f/cc with an average peak level of 16.00 f/cc; a level of 0.85 f/cc; a level of 0.33 f/cc with a TWA of 0.4 f/cc; and a range of 0.6 to 3.00 f/cc with an average peak level of 1.43 f/cc. The use of a dry brush or rag for two studies resulted in a range of 0.61 to 0.81 f/cc with a TWA of 0.19 f/cc and an average peak level of 0.70 f/cc; and a range of 1.3 to 3.6 f/cc with an average peak level of 2.5 f/cc. The use of a damp brush or rag resulted in a range of 0.67 to 2.62 f/cc with a TWA of 0.25 f/cc and an average peak level of 1.4 f/cc. The use of brake cleaner/compressed air resulted in a range of 0.25 to 0.68 f/cc with a TWA of 0.07 f/cc and an average peak level of 0.41 f/cc. (PEI Associates, 1985)

In another study, compressed air blown onto a wheel and brake assembly reported area levels at 3.17 and 2.48 f/cc (PCM), 5.39 and 11.75 (FIBERS> 5µm/cc, TEM), respectively. Personal samples ranged from 4.13 to 16.52 f/cc (PCM) (n=4) and <8.32 to 33.71 (FIBERS> 5µm/cc, TEM) (n=4), respectively. (Longo, 1998) In another similar report produced by Hatfield and Longo, they "conducted a study to determine exposures to airborne asbestos fibers generated while performing compressed air blowout on a brake assembly that contained non asbestos brake shoes, but contained residual asbestos contaminated brake dust from the previous shoe friction material." During the "1st Wheel Blowout" area samples ranged from 0.04 to 0.09 f/cc (PCM) (n=4), 1.32 to 3.98 (FIBERS> 5µm/cc, TEM) (n=4); while personal samples ranged from 0.52 to 1.03 f/cc (PCM) (n=4), 6.71 to 6.77 (FIBERS> 5µm/cc, TEM) (n=4). During the "2nd Wheel Blowout," area samples ranged from 0.07 to 0.11 f/cc with one sample overloaded (PCM) (n=4) and "None Detect" to 7.83 f/cc (FIBERS> 5µm/cc, TEM) (n=4); personal samples ranged from 0.56 to 1.72 f/cc (PCM) (n=4) and 6.77 to 40.63 (FIBERS> 5µm/cc, TEM) (n=4). Thirty minutes after compressed air use, area samples ranged from 0.01 to 0.03 f/cc with one sample overloaded (PCM) (n=4) and 0.19 to 0.96 (FIBERS> 5µm/cc, TEM) (n=4). They concluded that "[d]uring this process, significant amounts of asbestos fibers are released into the air." (Hatfield, 2001)

According to Hickish, atmosphere samples during car brake service by a car were 1.12 and 1.42 fibers/cm^3; atmosphere samples during car brake service in a “dust cloud then by car” were 1.71 and 3.62 fibers/cm^3; personal samples during brake services ranged from 0.21 to 1.12 (n=6); personal samples during truck brake service during and after cleaning was 7.09 and 0.08 fibers/cm^3, respectively; and during clutch repair procedures during cleaning and after cleaning, personal asbestos airborne levels were 2.25 and 0.11 fibers/cm^3, respectively. (Hickish, 1970) In a study by Lorimer, garage brake lining maintenance work for trucks, including the renewal of used linings by grinding resulted in asbestos airborne concentrations ranging from 1.7 to 5.6 fibers/cc (n=10). (Lorimer, 1975)

The US EPA states that “[w]hen grinding is done to renew used brake block linings, concentrations of up to seven million asbestos fibers per cubic meter can be released. Beveling new linings can release concentrations of up to 72 million fibers and light grinding of new linings of up to 4.8 million fibers.” With regard to clutch repair, “[s]ignificant exposure can also occur during clutch repair. Since a mechanic's head is typically under the clutch assembly during clutch repair, asbestos often falls on a mechanic's face and clothing.” (EPA, Brake Mechanics, 1986)

The literature is replete with asbestos exposure above background levels in the brake repair and maintenance industry. (Dodson, 2006) (Moore, 1988) (Weir, 2001) (Hickish, 1968) (Johnson, 1976) (Johnson/Zumwalde, 1979) (Cheng, 1986) (Paustenbach, 2003) (Boelter, 2007) (Rohl, 1977) (NIOSH, 1972) (Abex, 1972) (Ammco, Jan. 1973) (Ammco, June 1973) (Ammco, 1978) (Ammco, 1986) (Ammco, 1988) (Castlemen, 1975) (Sakai, 2006) (Lemen, 2004)

12. Asbestos-containing Joint Compound

“Spackling and drywall taping compounds consist of extremely fine-grained white powders or premixed pastes. Plaster of Paris is supposedly the major constituent, but other light-colored materials including clays, micas, quartz, talc, and ground limestone, supplement or replace the

plaster in many formulations. Chrysotile is added to some products, apparently because these minute fibers act as reinforcing agents." (Rohl, 1975) "[M]ost of the taping compounds used in the United States construction industry contained asbestos in the order of 4-5%. One compound contained 10-15% chrysotile and 8-12% tremolite." (Fischbein, 1979) In studies conducted between 1975 and 1977, Verma reported an asbestos content range of 3-6% in joint compound products. (Verma, 1980)

"Asbestos can be found in the workplace, particularly if you work or have worked as a(n)… Dry wall finisher…" (ATSDR, 2006) In a study conducted by the Gypsum Association which assessed asbestos exposure from the mixing and sanding of four dry joint compounds (two ready-mix and two dry mix), they state that "[b]ased on the results of the ten-minute samples, it is apparent that the exposures of workers engaged in mixing and sanding of the various joint compounds used during this test would be to concentrations approaching or exceeding five fibers, greater than five micrometers in length, per cubic centimeter of air." The mixing of the two dry mix joint compound products resulted in airborne asbestos concentrations of 31.4 and 7.7 fibers/cc. Of the concentrations not reported as "too heavily loaded for direct analysis," the sanding of the two dry mix joint compound products ranged from 3.7 to 43.6 fibers/cc (n=16). Of the concentrations not reported as "too heavily loaded for direct analysis," the sanding of the two ready-mix joint compound products ranged from 3.8 to 19.9 fibers/cc (n=15). (Soule, Gypsum Association, 1973)

A study conducted by the National Gypsum Association which assessed asbestos exposure from the sanding of three joint compound products for "Sanders" revealed TWA exposures that ranged from 0.5 to 2.5 fibers/cc (n=5) for ceiling work and from 0.3 to 1.3 fibers/cc (n=3) for sidewall work. "Assistants," standing 5 feet from the "Sander," revealed exposures that ranged from 0.3 to 1.4 fibers/cc (n=3) for ceiling work and from 0.4 to 1.2 fibers/cc (n=3) from sidewall work. Personal airborne asbestos concentrations (reported as a time–weighted average) during the pole sanding of the first product were 1.0, 1.0, and 1.0 fibers/cc. Regarding clean-up, the report states that "[t]he concentration was found to be 1.4 fibers per cc." (All Purpose Ready Mix – National Gypsum Co., 1973)

“Optical microscopic analysis of personal air samples obtained during the use of asbestos-containing compounds showed concentrations frequently in excess of the current occupational standard of 5 fibers per milliliter, longer than 5 µm. Use of these materials in home repair work (for example, mixing, sanding, and cleanup) may expose the user (and other members of the household) to significant concentrations of asbestos… It is, therefore, recommended that potentially toxic or hazardous materials be eliminated from consumer spackling, taping, and wall patching compounds as soon as feasible.” (Rohl, 1975) “Background measurements … suggest that in home repair work involving sanding of spackling compounds, members of the entire household or other occupants of a building may inhale asbestos fibers. This could occur during mixing, sand, or clean up of debris.” (Rohl, 1975) During pole sanding, personal airborne asbestos concentrations averaged 10.0 fibers/cc (n=10), while bystander airborne asbestos concentrations averaged 8.6 fibers/cc (n=3) and 4.8 fibers/cc (n=2); during hand-sanding, personal airborne asbestos concentrations averaged 5.3 fibers/cc (n=11), while bystander airborne asbestos concentrations averaged 2.3 fibers/cc (n=2) and 4.3 fibers/cc (n=2); during dry-mixing, personal airborne asbestos concentrations averaged 47.2 fibers/cc (n=2), while bystander airborne asbestos concentrations averaged 5.8 fibers/cc (n=3) and 2.6 fibers/cc (n=2). Asbestos airborne concentrations 15 minutes and 35 minutes after sweeping were 41.4 and 26.4 fibers/cc. (Rohl, 1975) (Fischbein, 1979) Fischbein stated that “[w]e found that taping workers in drywall construction have risk of exposure to asbestos. Our findings suggest that asbestos disease, as a result, is an important hazard in this trade…asbestos-related disease will inevitably be seen in taping workers in the future…the result of past exposure will be with us for some decades in the future.” (Fischbein, 1979)

Verma stated that “[t]he tapers are occupationally exposed to potential hazardous asbestos dust concentrations in their work…Sanding is the most hazardous operation of the taping process because the concentrations of asbestos encountered are high and a large portion total time is spent in the operation…The debris and the dust accumulated on the floor resulting from the mixing, application and sanding operations is generally cleaned up dry sweeping. In many instances, especially in cases of commercial buildings and large projects, this operation is carried out by general laborers…concentrations of 4 to 26.5 fibers/cc were measured.” (Verma, 1980) The

application of joint compound resulted in an average personal airborne asbestos concentration of 0.9 fibers/cc (n=10); the mixing of dry powder joint compound resulted in an average personal airborne asbestos concentration of 11.2 fibers/cc (n=3); mixing pre-mix joint compound resulted in average personal airborne asbestos concentration of 2.4 fibers/cc (n=7); mixing premix joint compound resulted in average area airborne asbestos concentration of 2.0 fibers/cc (n=7); hand-sanding joint compound resulted in an average personal airborne asbestos concentration of 11.5 fibers/cc (n=22); pole-sanding joint compound at three different locations resulted in average personal airborne asbestos concentrations of 4.3 fibers/cc (n=20), 4.6 fibers/cc (n=32), and 4.9 fibers/cc (n=52); pole-sanding joint compound resulted in an average area airborne asbestos concentration of 22.0 fibers/cc (n=10). Sweeping up at three different locations resulted in personal average airborne asbestos concentrations of 20.7 fibers/cc (n=6), 14.2 fibers/cc (n=4), and 18.1 fibers/cc (n=10). Overall, the averages for "All Operations" at three different sites were 17.5 fibers/cc (n=59), 18.5 fibers/cc (n=62), and 18.0 fibers/cc (n=121). (Verma, 1980)

In another study, the application of Georgia-Pacific Ready-Mix joint compound resulted in personal airborne asbestos concentrations that ranged from 0.5 to 0.7 fibers/cc (n=3) while area samples ranged from 0.01 to 0.06 fibers/cc (n=4); the hand sanding of Georgia-Pacific Ready-Mix joint compound after application resulted in personal airborne asbestos concentrations that ranged from 2.7 to 6.6 fibers/cc (n=6); the pole sanding of Georgia-Pacific Ready-Mix joint compound after application resulted in personal airborne asbestos concentrations that ranged from 1.4 to 6.1 fibers/cc (n=6); the cleanup, wiping, sweeping and hand brushing of Georgia-Pacific Ready-Mix joint compound resulted in personal airborne asbestos concentrations that ranged from 0.2 to 7.1 fibers/cc (n=12), while area samples ranged from 0.7 to 2.1 fibers/cc (n=12). In this study, a "Helper" through all processes ranged from 1.3 to 3.8 fibers/cc (n=12) and "Area" samples ranged from 0.5 to 1.9 fiber/cc (n=20). (Paskal, 2005)

Other studies have additionally shown exposure to asbestos above background levels during the use of asbestos-containing joint compound. (Hatfield, Long, Perf-A-Tape, 1999) (Hatfield, Long, Kelly Moore, 1999) (Kaiser Gypsum, 1974) (Longo, Hatfield, 2000) (Hatfield, Paskal, 2003) (Hatfield, Imperial QT, 1997)

13. Asbestos-containing Board Material

"Asbestos millboard is essentially a heavy cardboard product that can be used for gasketing, insulation, fireproofing, and resistance against corrosion and rot. The primary constituent of this product is asbestos fiber, with the balance consisting of binders and fillers. The asbestos content ranges from 60 to 95 percent, but 70 to 80 percent is considered typical." (ICF, 1989) Regarding phenolic board material, "In the present study, we evaluated the potential for release of asbestos fibers from mechanical manipulation of BMMA-5353, a phenolic molding compound that was manufactured…from the late 1960s through 1974. Phenolic molding compounds were commonly used to manufacture parts for automotive purposes and in appliances…The manufactured material is composed of a Novolac resin (a phenolic two-step resin) and contains 31% chrysotile asbestos (Jeffrey Mine 7RF-3) by weight." (Mowat, 2005) Regarding reinforced plastics, "In general, the raw asbestos fiber is 17 percent of the weight of the plastic." (ICF, 1989) In a 1999 study, "The analysis of the Micarta sheet indicated approximately 25-30% chrysotile asbestos with the balance of the sheet having paper filter and binders. The analysis of the Marinite center indicated approximately 35% amosite asbestos and the balance consisted of granular minerals, diatoms, and binders." (Longo, 1999) Fire-resistant board materials "usually contain 25 to 40 per cent of asbestos…" (Cross, 1971)

Harries describes asbestos-containing "millboard" as a dusty material. (Harries, 1968) In 1971, Harries reported an airborne asbestos concentration mean for "sawing and fitting perforated asbestos board" in a ship yard as 2.4 fibers/cm^3 (n=9). "Guillotining perforated asbestos board" resulted in an airborne asbestos concentration mean of 0.1 fibers/cm^3 (n=8). Fitting asbestos board inside a ship's galley resulted in an airborne asbestos concentration mean of 1.8 fibers/cm^3 (n=6). (Harries, 1971)

According to Carter, the cutting of 1 inch thick sheet Marinite™ with a band saw and with an air extract system resulted in airborne asbestos concentrations ranging from 4.2 to 71.0 fibers/cm^3 (n=8). The cutting of 1 inch diameter holes in 1 inch thick sheet Marinite™ with a

miller and with an air extract system resulted in airborne asbestos concentrations ranging from 0.061 to 0.43 fibers/cm^3 (n=6). The cutting of grooves in 1 inch thick sheet Marinite™ with a miller and with an air extract system, including the handling of sheet and cleaning up machine table Marinite™, resulted in airborne asbestos concentrations ranging from 0.51 to 3.2 fibers/cm^3 (n=4). Cutting annular grooves in 1 inch thick sheet Marinite™ with a lathe and with an air extract system resulted in airborne asbestos concentrations of 0.17 fibers/cm^3 and 0.15 fibers/cm^3. Cutting annular grooves in 1 inch thick sheet Marinite™ with a lathe and without an air extract system resulted in airborne asbestos concentrations of 7.7 fibers/cm^3 and 8.4 fibers/cm^3. Boring a 2½ inch diameter hole in 1 inch thick sheet Marinite™ with a lathe and with an air extract system resulted in airborne asbestos concentrations of 42.0 fibers/cm^3 and 7.5 fibers/cm^3. A worker handling, carrying and stacking sheets of Marinite™ in a ventilated shop resulted in airborne asbestos concentrations of 113.0 fibers/cm^3 and 53.0 fibers/cm^3. Cleaning Marinite™ dust from a table of miller with a vacuum extract pipe resulted in airborne asbestos concentration of 0.43 fibers/cm^3. Sweeping Marinite™ dust from a lathe bed with no extraction resulted in an airborne asbestos concentration of 53.0 fibers/cm^3. Brushing Marinite™ dust from 2½ inch diameter drill with no extraction resulted in an airborne asbestos concentration of 7.7 fibers/cm^3. Sweeping Marinite™ dust in an unventilated room resulted in airborne asbestos concentrations ranging from 18.0 to 25.0 fibers/cm^3 (n=3). Sweeping Marinite™ dust in a ventilated room resulted in an airborne asbestos concentration of 3.2 fibers/cm^3. (Carter, 1970)

In a 1999 work practice study, a "Micarta board" consisted of a sheet of "Marinite™ sandwiched between two identical sheets of Micarta™. The analysis of the Micarta™ sheet indicated "…approximately 25-30% chrysotile asbestos with the balance of the sheet having paper filter (sic) and binders. The analysis of the Marinite center indicated approximately 35% amosite asbestos, and the balance consisted of granular minerals, diatoms, and binders." The work practice included the sawing of Micarta™/Marinite™ board with a 7 ¼ circular saw as well as the

subsequent cleanup with a broom and dustpan. Two area asbestos airborne levels during this work practice were 48.1 fibers/cc and 53.7 fibers/cc. Four personal asbestos airborne levels during this work practice were 78.1 fibers/cc, 82.5 fibers/cc, 77.1 fibers/cc and 81.1 fibers/cc. (Hatfield, Micarta, 1999)

In a 2001 work practice study, "[t]he work activity consisted of sawing a piece of Marinite panel approximately 18 inches wide and 5/8 of an inch thick twice with a skill saw equipped with a plywood blade." During this activity, three of four area airborne asbestos samples were "overloaded" and the fourth was 37.5 fibers/cc. Four personal samples were reported as 154.3 fibers/cc, 159.9 fibers/cc, 141.9 fibers/cc and 97.1 fibers/cc. (Hatfield, Micarta, 2001)

Cross reports that the cutting of "Incombustible board" material without exhaust to be 100.0 fibers/cc, while cutting this material with a portable exhaust in place ranged from 1.1 to 4.5 fibers/cc. Drilling "Incombustible board" material without exhaust resulted in a range of 1.0 to 1.9 fibers/cc, while drilling this material with a portable exhaust in place ranged from 0.7 to 0.9 fibers/cc. (Cross, 1971)

In 2005, a study was conducted to determine the exposure from band sawing, sanding, and drilling of phenolic molding materials (Bakelite). For personal sawing, the results ranged from <0.05 to 0.23 f/cc (PCM) with an average of 0.13 f/cc (PCM), for personal sanding, the results ranged from <0.05 to 0.09 f/cc (PCM) with an average of 0.06 f/cc (PCM), for personal drilling, the results <0.04 to 0.07 f/cc (PCM) with an average of 0.05 f/cc (PCM), and for personal "sweep cleanup tests," the results <0.05 to 0.18 f/cc (PCM) with an average of 0.07 f/cc (PCM). For area sawing, the results ranged from <0.04 to 0.35 f/cc (PCM) with an average of 0.10 f/cc (PCM), for area sanding, the results ranged from <0.05 to 0.09 f/cc (PCM) with an average of 0.06 f/cc (PCM), for area drilling, the results <0.02 to 0.02 f/cc (PCM) with an average of 0.02 f/cc (PCM), and for area "sweep cleanup tests," the results <0.02 to 0.08 f/cc (PCM) with an average of 0.03 f/cc (PCM). (Mowat, 2005)

14. Asbestos-containing Cement

"Asbestos-cement pipe is made of a mixture of Portland cement (42 to 53 percent by weight), asbestos fibers (15 to 25 percent by weight), and silica (34 to 40 percent by weight)." (ICF, 1989) "Flat asbestos-cement sheet is made from a mixture of Portland cement, asbestos fiber, and silica….In the past, sheets usually contained between 15 and 40 percent asbestos fiber with Portland cement and silica accounting for the rest (ICF 1985). However, Nicolet, the only remaining U.S. producer of asbestos-cement flat sheet has a formulation containing 45.6 percent asbestos (ICF 1986)." (ICF, 1989) "Asbestos-cement corrugated sheet is made from a mixture of Portland cement and asbestos fiber. An additional fraction of finely ground inert filler and pigments is sometimes included (Krusell and Cogley 1982). In general, sheets contain between 15 and 40 percent asbestos fiber, although, for curing in short time periods, a general formulation of 12 to 25 percent asbestos, 45 to 54 percent cement, and 30 to 40 percent silica is used (Cogley 1980)." (ICF, 1989) "The PLM analysis showed that the Certain-Teed cement pipe contained 20% chrysotile and 1% crocidolite asbestos as determined by the recommended Environmental Protection Agency protocol for this analysis." (MAS, 2002)

Harries describes asbestos "cement" as a dusty material. (Harries, 1968) When discussing the mixing of asbestos cement with regards to installation, Fleischer states that "[i]n mixing, the proper amount of water is added to the dry asbestos cement and thoroughly agitated with a hoe. Occasionally small amounts of asbestos cement are mixed in a pail with a trowel. Considerable dust is raised when asbestos cement is dumped into the mixing trough and during the early stages of mixing." (Fleischer, 1946) In one study, the average level of airborne asbestos from mixing was reported to be approximately 1.5 f/cm^3. (Balzer, Industrial Hygiene, 1968) Hatfield and Longo reported airborne asbestos levels in the breathing zone at 3.24 and 5.98 fibers/cm^3 when "pouring a small amount (1 to 2 cups) of the insulating cement from a bag into a container. Since only a small amount of the insulating cement was available, the cement was poured back and forth approximately 6 times to simulate the pouring of a larger amount of cement." Area samples were reported at 1.56 and 1.57 fibers/cm^3. (Hatfield, 1999) The US Navy discusses the

proper use of asbestos-containing cements. “In-Shop operations for mixing of all cement will be provided with permanent exhaust ventilation equipment. This exhaust air will not be vented into the shop atmosphere and must be adequately filtered before its release to the outside atmosphere.” (Navy, 1971) According to a NIOSH publication, cement dry mixing was employed in a number of work situations. Mixing dry asbestos cement in a high ceiling room with a louvre vent reported a personal airborne asbestos level of 2.4 fibers/ml, and an area asbestos level of 0.45 fibers/ml. Mixing dry asbestos cement in a room with a low ceiling and poor ventilation reported a personal airborne asbestos level of 2.6 fibers/ml. Mixing dry asbestos cement in an access tunnel reported a personal airborne asbestos level of 6.1 fibers/ml. Mixing asbestos cement in a powerhouse with a low ceiling and poor ventilation reported a personal asbestos level of 3.9 fibers/ml and an area asbestos level of 2.5 fibers/ml. (NIOSH, 1972)

The Equitable Environmental Health, Inc. reported that the unloading and laying of asbestos-containing cement pipe resulted in asbestos airborne concentrations ranging from below the detection limit to 0.03 fibers/ml (n=4). The level of airborne asbestos in the breathing zone while hacksawing asbestos containing pressure pipe ranged from 0.0 to 0.06 f/cc (average 0.01 f/cc) (n=3) and the “Helper” had an airborne concentration that ranged from 0.05 to 0.11 f/cc (average 0.11 f/cc) (n=3). The airborne concentration of the individual hacksawing the asbestos containing sewer pipe ranged from 0.11 to 0.23 f/cc (average 0.18 f/cc) (n=3) and the “Helper” had an airborne concentration that ranged from 0.0 to 0.17 f/cc (average 0.08 f/cc) (n=3). The level of airborne asbestos in the breathing zone and general atmosphere during electric saw cutting of asbestos containing pipe was accomplished with an “…abrasive disc saw (Stihl) saw with a 10-inch carbide blade…” The airborne concentration of the individual cutting the asbestos containing pressure pipe ranged from 25.0 to 109.1 f/cc (average 65.0 f/cc) (n=4) and the “Helper” had an airborne concentration that ranged from 46.0 to 54.0 f/cc (average 49.2 f/cc) (n=4). The airborne concentration of the individual cutting the asbestos containing sewer pipe ranged from 11.3 to 95.3 f/cc (average 42.1 f/cc) (n=3) and the “Helper” had an airborne concentration that ranged from 7.0 to 14.4 f/cc (average 10.2 f/cc) (n=3). Other data is reported for various other cement pipe work (e.g. lathe, drilling, etc.). (Equitable Environmental Health, Inc., 1977)

In the Materials Analytical Services, Inc. (MAS) study, they report the level of airborne asbestos in the breathing zone and general atmosphere during electric saw cutting of Certain-Teed asbestos containing pipe. The cutting of the pipe was accomplished with a Skil saw with a new DeWalt abrasive saw blade. Personal samples collected during the cutting ranged from 171.3 to 247.8 PCM fibers/cc (n=4), 2,566.1 to 11,276.5 TEM Str/cc (All) (n=4), and 721.7 to 2,013.7 TEM fibers ≥ 5 µm/cc (n=4). Area samples ranged from 34.7 to 86.0 PCM fibers/cc (n=4), 986.7 to 8,383.2 TEM Str/cc (All) (n=4), and 302.1 to 3,193.6 TEM fibers ≥ 5 µm/cc (n=4). Area samples "Collected 95 Minutes After Area Samples" ranged from 7.8 to 9.9 PCM fibers/cc (n=4), 16.9 to 33.3 TEM Str/cc (All) (n=4), and 2.3 to 8.5 TEM fibers ≥ 5 µm/cc (n=4). (MAS 2002)

In the work environment, asbestos-containing dust exposure above background levels is associated with the mixing of thermal or finishing cement and cement pipe and can be described further in the literature. (Fontaine, 1975) (Balzer, Environment, 1968) (Merewether, 1930) (Harries, 1971)

15. Asbestos-containing Wire

According to the National Electrical Code, Table 310-2(a), the following designations have been assigned to asbestos wiring: Silicon-Asbestos (SA), Asbestos and Varnished Cambric (AVA, AVL, or AVB) and Asbestos (A, AA, AI, or AIA). (NEC, 1971) "A sample of the wire from each manufacturer was analyzed by polarized light microscopy (PLM). The results showed that Sample 1 (Atlas Wire) was found to contain 90% chrysotile and the outside cover on Sample 2 (Carol Wire) was found to contain 10% chrysotile." (Longo, 1999)

Harries describes electrical fitters as an occupation that were "NOT (sic) recognised asbestos workers" but were workers that had contracted asbestosis. (Harries, 1968) When looking at the "prevalence of pleural plaques in routine PA chest films in shipbuilding and engineering workers over the age of 24", of the 232 electricians noted, 9.1% were identified with this condition. (Fletcher, 1971) [PA = posteroanterior] The hazard to electricians is additionally recognized by

Jones and Brogan. (Mangold, 1970) (Brogan, 1983) According to the ATSDR, “Asbestos can be found in the workplace, particularly if you work or have worked as a(n): Electrician,…” (ATSDR, 2006)

In a Longo study, asbestos-containing electrical wire from two different manufacturers were used. “The work activity consisted of pulling the two types of AF wire through two pieces of 3/4 inch conduit that was 18 feet in length. The appropriate amount of Atlas AF wire was removed from the spool (approximately 20') and used as a template for the other pieces of AF wire used in this study. For the north conduit line, two pieces of Atlas AF wire was pulled simultaneously and for the south conduit, three pieces of Carol AF wire was pulled at the same time. Approximately 2” of the AF wire was first stripped and attached to pull the wire. After the pull, the AF wire was cut and restripped.” (Longo, 1999) One wire insulation contained approximately 90% asbestos, while the other contained 10% asbestos. Asbestos air samples were analyzed using PCM and TEM methods. Area samples, analyzed using PCM, were 0.22 and 0.31 fibers/cc, while personal samples, analyzed using PCM, ranged from 0.18 to 0.47 fibers/cc. Area samples, measuring fiber structures greater than 5µm using TEM, were 1.58 and 4.63 “Fibers>5µm/cc.” Personal samples, measuring fiber structures greater than 5µm using TEM, ranged from 2.37 to 55.33 “Fibers>5µm/cc.” The author concludes that when pulling these two types of wires through a conduit pipe “will cause significant release of asbestos fibers into the air.” (Longo, 1999)

In a Millette study, four different asbestos-containing cables, 1.125 or 1.25 inch diameter in size, were stripped. Personal asbestos airborne concentrations during “Stripping” of Cable 1 were <0.05 and 0.11 fibers/cc. Personal asbestos airborne concentrations during “Sweeping” of Cable 1 were <0.2 and <0.5 fibers/cc. Personal asbestos airborne concentrations during “Stripping” of Cable 2 were <0.04 and <0.1 fibers/cc. Personal asbestos airborne concentrations during “Sweeping” of Cable 2 were <0.4 and <0.6 fibers/cc. Personal asbestos airborne concentrations during “Stripping” of Cable 3 were <0.04 and <0.1 fibers/cc. Personal asbestos airborne concentrations during “Sweeping” of Cable 3 were <0.2 and <0.5 fibers/cc. Personal asbestos airborne concentrations during “Stripping” of Cable 4 were 0.06 and <0.1 fibers/cc. Personal asbestos airborne concentrations during “Sweeping” of Cable 4 were <0.3 and <0.6 fibers/cc.

(Millette, 1999) In an asbestos abatement guideline for the military, asbestos containing wire insulation is removed using certain techniques to minimize the release of fibers into the air. “Adequately wet mist exposed asbestos insulation with removal encapsulant. Carefully remove wiring so as not to damage insulation. Coil wire and place in approved container…” (Army, 1997)

16. Asbestos-containing Cloth

“Asbestos textiles are produced by standard textile production techniques involving carding, combing, and spinning of the asbestos fibers. Asbestos fibers can be blended with other types of fibers to give the resulting textile products added tensile strength.” (ICF, 1989) “Pipes and machinery have been insulated with moulded sections containing from 15-90 per cent amosite asbestos. These fragile sections were covered with a protective layer of chrysotile asbestos cloth.” (Harris, 1971)

According to Mar, installing asbestos-containing cloth (80-95% chrysotile) resulted in an airborne dust concentrations ranging from 0.3 to 1.8 mppcf (2-5 micron range), and 0.2 to 1.4 mppcf (5-10 micron range); while the removal of this asbestos-containing cloth resulted in an airborne dust concentrations ranging from 0.2 to 1.9 mppcf (2-5 micron range), and 0.5 to 2.0 mppcf (5-10 micron range). (Mar, 1964) Ripping “treated” cloth resulted in personal airborne asbestos concentrations averaging >1.0 fibers/cc (n=12), while atmosphere airborne asbestos concentrations also averaged >1.0 fibers/cc (n=12). Ripping untreated cloth resulted in personal airborne asbestos concentrations averaging 7.0 fibers/cc (n=5), while atmosphere airborne asbestos concentrations averaged 33.0 fibers/cc (n=2). Fitting cloth over lagged pipe resulted in personal airborne concentrations of 22.0 fibers/cc (n=7). (Harries, 1971)

In a study by Mangold et al., the cutting, fitting, and gluing of asbestos-containing cloth (80-95% chrysotile or amosite) resulted airborne asbestos concentration averages of 4.3 and 3.6 mppcf in ship overhaul and new ship building, respectively. Cutting, fitting, and sewing of this asbestos-containing cloth in prefabrication resulted an airborne asbestos concentration average of

0.2 mppcf. (Mangold, 1970) According to Cross, various asbestos cloth involving "conventional use" resulted in airborne asbestos concentrations ranging from 5.0 to 10.0 fibers/cc; for "dust suppressed use", 1.0 to 3.0 fibers/cc; for "new process use", 0.2 to 1.5 fibers/cc; and for ripping conventional asbestos cloth, 6.6 fibers/cc. (Cross, 1971) In 1968, the application and stitching of asbestos cloth resulted in airborne asbestos concentrations ranging from 0.05 to 0.26 fibers/cc. (Harries, Asbestos Hazard, 1968)

17. Asbestos-containing Spray Applied Materials

"Sprayed inorganic fiber insulation was introduced in 1932 with the Limpet process…In 1935 the spray process was first used in the United States. Most of the material applied during the late 1930's was used for decorative finishes in night clubs, restaurants, hotels, etc…Mineral fiber materials containing asbestos have four major insulation uses in construction and shipyard industries: (1) fireproofing, (2) thermal insulation, (3) acoustical and decorative purposes, and (4) condensation control…The material used for fireproofing in building construction usually is a blend of 5 to 30% asbestos fiber (Chrysotile), mineral wool, clay binders (as bentonite), adhesives, synthetic resins, and other proprietary agents such as oils…In 1968 an estimated 40,000 tons of material were used for fireproofing alone" (Selikoff, 1972) "In 1970, more than half of all multistory buildings constructed in the U.S. contained sprayed inorganic fibers as a fireproofing agent. The material usually contains 5 to 35% asbestos fibers, mineral wools, clay binders, adhesives, synthetic resins, and other proprietary agents such as oils." (Brogan, 1983) EPA report in a "Summary of Asbestos-Containing Products" that surfacing material, sprayed or troweled-on, contained 1 to 95 % asbestos from 1935 to 1970. (EPA, NESHAP, 1990)

In the Selikoff et al. report, fireproofing is described as "cementitious", containing 5 to 30% asbestos fibers. In this study men "at the nozzle" during the application of asbestos-containing fireproofing material had exposures from 20.0 to 99.0 fibers/cc (n=10). According to Selikoff, the group involved with application was considered to be the "most heavily exposed." Area or stationary samples collected at various distances between 15 to 75 ft, ranged from 10.0 to 71.0 fibers/cc (n=7). After spray operations had ceased for 30 minutes, area or stationary samples

ranged from 1.01 to 4.22 fibers/cc (n=4). After spray operations had ceased for 60 minutes, area or stationary samples ranged from 0.26 to 0.76 fibers/cc (n=5). (Selikoff, 1972) In a 1971 review it was mentioned that during the application of sprayed asbestos coatings "concentrations of as much as 1,500 fibres/ml have been reported, though a level of 200-300 fibres/ml is more normal." Specifically, "undamped" spraying of asbestos produces airborne asbestos levels ranging from 173.0 f/ml to 322.0 f/ml; for "predamped" spraying, it was 1.7 to 4.7 f/ml. In this same review, air samples were collected over the spray operators shoulder, at his feeding machine, at his feeding damping drum, and at two different distances away; both "predamped" and "undamped." Without "predamping," at the operators shoulder the level was 1,500.00 fibres/ml; at his feeding machine, 150 fibres/ml; 9 meters away from the operator, 19-37 fibres/ml; and 18 meters from the operator, 12 fibres/ml. "Predamped" processes were lower but all above 1 fibres/ml. (Cross, 1971) In 1970, Zonolite Construction Products Division conducted in-house exposure studies concerning Monokote fireproofing. According to five of their studies at several buildings: 1) At the Grumman Aircrafts Data Processing Research Center in Bethpage, N.Y., personal samples of spraying 10' overhead, spraying 3' overhead, mixing, and general area asbestos concentrations were 2.6, 1.1, 1.3, and 0.4 fibers/cc (>5µm), respectively. 2) At the First National Building at Omaha, 10th Floor, personal samples of spraying 1-3' overhead and vertical, mixing, and general outside, asbestos concentrations were 0.7, 0.9, and 1.1 fibers/cc (>5µm), respectively. 3) At the PG & E Building, two personal samples collected at the breathing zone of the operator, the breathing zone of the investigator, the mixing operators breathing zone with wind towards, and the mixing operators breathing zone with wind away produced asbestos concentrations of 2.91, 2.64, 0.14, 0.42, and 1.25 fibers/ml (>5µm), respectively. Area samples were also collected from ± 40 feet upwind, ± 40 feet downwind, in-between two mix operators twice, one floor above work area, ± 30 feet from stages, and ± 35 feet from stages. The levels produced were 0.11, 0.23, 0.98, 1.14, 0.011, 0.061, and 0.34 fibers/ml (>5µm), respectively. 4) At the Embarcadero Center, air samples were collected at the spray operator's breathing zone twice, another at the back of his head, the Stage mover's breathing zone, the area near spray (approximately 1-50ft distance), the background area (43rd floor), the investigators breathing zone, and the mixing operator's breathing zone. The levels detected were 6.54, 2.18, 3.18, 1.55, 0.028, 0.016, 0.60, and 0.710 fibers/ml

(>5µm), respectively. 5) At the Hilton Towers, air samples were collected at the spray operator's head, the hod carrier's head, the mixing operators breathing zone twice, and in the mixing area. The levels detected were 2.20, 0.33, 1.45, 0.50, and 0.38 fibers/ml (>5µm), respectively. (Egan, 1970)

P.G. Harries found that during the removal of blue sprayed asbestos, levels fell in the range of 112.0 -1,906.0 fibers/cm^2. (Harries, 1968) In another study by Harries during the removal of sprayed crocidolite asbestos in an aircraft hangar and adjacent areas including sweep up, levels ranged from 19.0 to 493.0 fibers/cc. (n=30) (Harries, Naval Dockyards, 1971) An additional Harries studies reveals asbestos exposure to in-place spray applied asbestos in storehouses. "Hardly any activity" in the storehouse resulted in asbestos airborne concentrations ranging from 0.01 to 1.26 fibers/cc (n=8); "a lot of activity (approx. 50 employees handling stores)" resulted in a range of 0.03 to 10.31 (n=8); "disturbing fallen asbestos on boxes or the floor" resulted in a range of 0.03 to 52.6 fibers/cc (n=16); "no activity" resulted in a range of 1.7 to 2.0 fibers/cc (n=3); "moving boxes" resulted in a range of 4.8 to 7.6 fibers/cc (n=2); "brushing cement facing overlying unprotected sprayed asbestos" resulted in an airborne asbestos concentration of 3.75 fibers/cc; and "brushing unprotected sprayed asbestos" resulted in an airborne asbestos concentration of 350.0 fibers/cc. (Harries, Building Insulated, 1971) Brogan et al. maintains that "workers are heavily exposed to asbestos when they remove sprayed fireproofing material without using wetting agents." In this study, dry removal of asbestos-containing fireproofing ranged from <0.1 to ≤200.0 fibers/cc, with a geometric mean of 16.4 fibers/cc (n=79). The dry removal of asbestos-containing fireproofing ranged from <0.1 to ≤10.0 fibers/cc (n=15), with a geometric mean of 0.5 fibers/cc. (Brogan, 1983) Eight O&M procedures were simulated over several years and reported in a 1994 paper. Three of the simulations involved asbestos-containing fireproofing, specifically, moving walls, cleaning underneath exposed fireproofing on beams, and ceiling tile replacement. Area samples were analyzed using TEM, and all personal samples were analyzed using both PCM and TEM. Specifically looking at "personal" TEM analysis with structures > 5µm during the activity of moving walls, the arithmetic mean was 2.43 s/ml; for the cleanup activity it was 12.3 s/ml; and for ceiling tile replacement both during on through

cleaning, it was 1.10 and 1.43 s/ml. (Keyes, 1994) Brogan et al. looked at the activities of Carpenters, Electricians, Sheet-metal Workers, and Painters in relation to work near or on asbestos-containing fireproofing. The range of asbestos fiber concentrations for each job description was <0.05 to >2.0 f/cc. (Brogan, 1983)

A study in 1991 was conducted involving cable installation in a building with known asbestos-containing fireproofing above a suspended ceiling. The purpose was to simulate an activity "…that may disturb in-place asbestos and associated dust and debris." The arithmetic mean for both simulations before installation was 0.052 and 0.158 structures/cm^3; during installation (area samples), 28.9 and 100.2 structures/cm^3; during installation (personal samples), 10.5 and 124.8 structures/cm^3; and after installation, 8.4 and 17.0 structures/cm^3. (Keyes, 1991) A similar study, Ewing, Hays, Longo, Millette, et al. showed the arithmetic mean ranging from 0.006 to 58.0 structures/cm^3 (n=24). This included sample collection before installation, through installation, and concluding in cleaning procedures. (Ewing, 1993) Additional exposure to asbestos above background levels from fireproofing above background can be seen in the following studies: (Ontario Dept. of Health, 1971) (Brown, 1972) (Newson, 1972) (Keyes, 1994)

In a 1998 study in which a bag of USG "Audicote" acoustical plaster was mixed in a hopper in a controlled environment, personal asbestos dust levels analyzed using PCM ranged from 55.1 to 142.3 fibers/cc (n=3), while area asbestos dust levels analyzed using PCM were 294.7 and 433.0 fibers/cc. (Hatfield, 1998) In a 1997 simulation study, a portion of USG "Imperial QT", a spray-applied product, was mixed with water in a hopper, under controlled conditions, and applied to a wall surface. Specifically, samples were collected during the sanding of the Imperial QT as well as the subsequent cleanup. Samples were analyzed with PCM and TEM. During the sanding demonstration, area TEM ($\geq$ 5.0µm) asbestos air samples ranged from 52.10 to 781.34 fibers/cc (n=4); personal TEM ($\geq$ 5.0µm) asbestos air samples ranged from 23.76 to 71.29 fibers/cc (n=4). During cleanup, area TEM ($\geq$ 5.0µm) asbestos air samples ranged from 0.39 to 2,577.44 fibers/cc (n=4); personal TEM ($\geq$ 5.0µm) asbestos air samples ranged from 99.80 to 794.91 fibers/cc (n=3). (Hatfield, 1997)

In the study "Baseline Studies of Asbestos Exposure During Operations and Maintenance Activities," certain simulations were conducted in a building in which acoustical plaster was present on the ceiling. Light fixture maintenance, plaster repair and carpet removal simulations were conducted. Area samples were analyzed using TEM, and all personal samples were analyzed by both PCM and TEM. Specifically looking at TEM analysis with structures > 5µm (personal), during the activity of fixture maintenance 1, 2, and 3, the arithmetic means were 0.40 (n=3), 4.95 (n=2), and 0.00 s/ml (n=4), respectively. Arithmetic mean of the area samples were 0.54 (n=5), 3.08 (n=5), and 0.07 s/ml (n=6), respectively. During the plaster repair simulation, the personal arithmetic mean was 1.13 s/ml (n=2), while the area arithmetic mean was 1.52 s/ml (n=5). During the carpet removal simulation the personal arithmetic mean was 0.90 s/ml (n=2); while the area arithmetic mean was 2.35 s/ml (n=5). (Keyes, 1994) In a Yale building with suspended gypsum ceiling board sprayed with a mixture of asbestos, fibrous glass, and cementitious binder, activities such as various impacts to the ceiling and subsequent dispersal activities were studied with regard to airborne asbestos concentrations. During impact, mean levels ranged from 1.4 to 17.1 f/cm^3 (n=8), and during dispersal activities, mean levels ranged from 0.2 to 4.0 f/cm^3 (n=47). (Sawyer, 1977)

In a 1992 study, a Greenville, South Carolina, gymnasium and accompanying Jolly Room with asbestos-containing acoustical plaster applied to the ceiling were used for several simulations. The study was to represent common daily activities in a gymnasium environment (e.g., playing basketball, tumbling, and dry sweeping of visible dust). The "Athletic Activity" samples (area and personal, arithmetic mean) for the gymnasium were 0.230 and 0.582 structures/cc; the "After" (area, arithmetic mean) sample was 0.021 structures/cc. The "Cleaning" samples (area and personal, arithmetic mean) for the Jolly Room was 3.123 and 2.781 structures/cc, respectively, and the "After" (area, arithmetic mean) samples, 0.384 structures/cc. The "Before" (area, arithmetic mean) samples for the Gymnasium and the Jolly Room were 0.0 and 0.314 structures/cc, respectively. (Keyes, 1992)

18. Asbestos-containing Materials in Electrical Switchgears

Asbestos-containing materials in switchgears have been identified as asbestos rope packing (Application: stuffing box on oil circuit breakers, aluminum melting pots, flood lights, arch chute assembles, gasketing material in dust tight fluorescent luminaires, seal between arc chute top baffle and edge of interrupter plates of DH circuit breakers, and blocking end turns of turbo-generators), asbestos cement sheets (Application: switchboard bases, switchboard panels, safety switch bases, arc shield & heat resisting applications, arc baffles, arc chute liners in air switches for transformers, switchgear assemblies, and barriers on electro pneumatic switches), and ungraphited compressed asbestos sheet packing (Application: gaskets). (ACM in Switchgears)

Instructions Westinghouse circuit breakers states "[t]he insulation parts of the arc chute remain in the circuit across the contacts at all times. During the time that the contacts are open, these insulating parts are subjected to the full potential across the breaker. Ability to withstand this potential depends upon the care given the insulation…On general inspections, blow-out the arc chutes with **dry compressed air by directing the stream upward** from the contact area and out through each of the slots between the arc splitter plates. Also direct the dry air stream thoroughly over the arc shields. These are the ceramic liners in the lower end of the chute where the arc is drawn. The arc shuts should be inspected each time the contacts are inspected. Remove any residue, dirt, or arc products with a cloth or a light sanding." {emphasis added} The recommendation to direct the compressed air stream upward will spread the asbestos-containing dust over a wider area and increase the likelihood of bystander exposure. (Porcel-line Type DH-P, 1968)

A Westinghouse memo states that "[p]rior to 1977 all type DH and DHP breaker arc chute were built with asbestos rope spacers between the ceramic plates of the interrupter stack assembly…The assemblies were held together with white baking enamel which covered the asbestos rope except for the 1/8" exposed surface between the ceramic plates…In addition to the asbestos rope DH and DHP arc chutes, depending on the rating and vintage, may have some

pieces of asbestos cement board in them…This material is still being used…Under normal handling or operation, fiberous (sic) asbestos is not given off. If the breaker has undergone a major fault current interruption, there is a remote possibility that a few fibers of asbestos could be released…Therefore, prior to the breaker being examined for maintenance or other reasons, the following procedure should be used….When de-energized, any particulate matter should be removed by a damp cloth from inside of the cubicle and the exterior of the breaker and arc chute assembly…When cleaning the interior of arc chutes, which involves blowing dry compressed air thru them, some fiberous (sic) asbestos may be blown off. Therefore, personnel should be protected using NIOSH approved personnel protection equipment." (Air Circuit Breakers - Asbestos, 1985)

"Ceramic arc chutes containing asbestos are produced by General Electric and are used to guide electric arcs in motor starter units in electric generating plants. Asbestos is used in the arc chutes for its strength, heat resistance, and dielectric strength (General Electric 1986)…General Electric Company is the only processor of asbestos-containing ceramic arc chutes. There are, however, other processors of asbestos arc chutes, but they manufacture plastic arc chutes that have been classified in the asbestos-reinforced plastic category…Generally, the plastic arc chutes are smaller and are not able to withstand as high a temperature (above 1500°F) as the ceramic arc chutes. The plastic arc chutes are used in smaller electric motors, often in the automotive and appliance industries (ICF 1986)." (ICF, 1989)

"Asbestos is used in electrical paper insulation because of its high thermal and electrical resistance that permit the paper to act effectively as an insulator and to protect the conductor from fire at the same time. Asbestos electrical insulation is composed of 80 to 85 percent asbestos fiber encapsulated in high temperature organic binders. It is formed on conventional papermaking machines and may be obtained in rolls, sheets, and semi-rigid boards (ICF 1986). The major use of asbestos electrical paper is insulation for high temperature, low voltage applications such as in motors, generators, transformers, switch gears, and other heavy electrical apparatuses. Typically, operating temperatures are 250°Fto 450°F (ICF 1986)." (ICF, 1989)

Medium-Voltage Replacement Breaker Projects states that “[m]ost of the original arc chute designs were made with asbestos…These older breakers require special environmental procedures during removal and inspection of the arc chutes…The process of switching load current contaminates the bottom portion of the arc chute with conductive material. The arc melts and vaporizes the contact material and portions of the metal vapor and oxides condense on the surround insulating surfaces, decreasing the insulation resistance. Repetitive arc interruption at low current levels will increase the contamination and under severe conditions; the circuit breaker will not withstand the interrupted circuit (transient recovery) voltage, resulting in failure to interrupt the current. In the past, recondition of an arc chute was typically accomplished by lightly bead blasting the contaminated surfaces. This activity resulted in airborne asbestos…The arc chute is a sophisticated mechanism typically containing arc runners, ceramic/asbestos stacks, arch shields, blow out coils, baffles and deflectors, and a magnetic structure, all assembled in a insulating jacket.” (Bowen, 2002)

Safety and Environmental Evaluation of Insulating Media in Medium-Voltage Distribution Equipment states that “[o]n July 12, 1989, the United States Environmental Protection Agency (EPA) established a ban on new uses of asbestos. Prior to this date, however, asbestos was utilized as an insulating and high temperature sealing material in some switchgear and circuit breakers…During normal equipment operation, asbestos based insulating materials are not disturbed, thus posing little danger to personnel. Some air-break circuit breakers utilized asbestos in their arc shuts to seal-in the high temperature arc byproducts. Even during normal arc interruption, insignificant amounts of asbestos are potentially dislodged. The periods in which workers would have the opportunity to be exposed to higher than normal levels of asbestos are during cleaning of arc chutes during periodic maintenance or repair, decommissioning of vintage equipment, or after an equipment failure. These situations have the potential for dislodging and spreading much higher levels of asbestos into the air…Equipment built prior to 1989 should be investigated for the presence of asbestos.” (Yanniello, 2008)

Asbestos Containing Archshields used in Electrical Switchgear states that “Arcshields can be found in switchgear that is used in virtually any industrial or commercial premises that require a high voltage supply of electricity…Archsields provide an insulating barrier in electrical switchgear, which prevents flashover between phases when the circuit breaker is activated. Asbestos continued to be used in arcshields until the mid 1980s. Typically the arcshield components contain up to 50% chrysotile asbestos (ie the arcshield and separator plates may contain ~20% and ~50% respectively) and have a density greater than 1 tonne/m^3. The extent of activation will depend on the use pattern for the pattern for the parent machine or equipment. The degree of deterioration of the asbestos material will be related to the extent of activation and flashover. The asbestos material may suffer surface deterioration or scorching and possibly become cracked or broken in extreme cases…It should be assumed that all equipment manufactured before the mid 1980s contains asbestos…The work activity involves primarily visual inspection of the condition and lifting/handling of the arcshield unit as part of a wider maintenance procedure. Asbestos is not being removed or undergoing any direct insult such as drilling or cutting. However, as there is likely to be some loose (albeit minor) asbestos containing dust to contaminate hands (or gloves) by direct contact and for potential of dust through movement of the drawer unit or lifting out the arcshield. The amount of dust or even debris will be expected where there is more physical damage or surface deterioration. This will increase the potential for exposure and spread.” (HSE, 2005)

GE Arc Chute Cement Materials was shown to contain 20-40% Chrysotile asbestos (Asbestos Air samples collected during the sanding and using compressed air revealed personal air samples of 3.9 to 3.8 f/cc and an area sample of 2.0 f/cc (MVA, 2011).

19. Asbestos-containing Materials in Electrical Motors

Asbestos containing materials identified in electrical motors are rope packing (used as dam lead seal and as packing in cable gland on explosion proof motors), treated paper (heated and bonded in place as turn insulation in edge wound DC field coils), tape (used a lugging and between coil

insulation on DC main field coils), paper (used as turn insulation in bare strap DC field coils), cloth (used as insulating and cushioning pads between loops and leads of coils and bands in DC armatures), Micarta plate (used for DC armature slot wedges), Micarta tubing (used for DC armature coil supports), cable (Asbestos-Mylar insulated, glass braid covered cable used for AC stator connections and leads and DC wiring frame connections and leads), and brake lining (used as lining on brake shoes of AC and DC brakes). (Asbestos Applications in LMD Products, 1976 and Asbestos Substitution Program, 1976) In addition, the National Electrical Manufacturers Association has developed classes of insulation for motors. These classes of insulation have been defined as Class A, Class B, Class F, and Class H, where Class B, Class F, and Class H may be asbestos containing. (Videotaped Deposition of Ray McMullen, June 9, 2011) According to General Electric, "Insulation is one of the most important factors in the life and service of electric apparatus. When insulation fails, the machine is out until new insulation is applied…Some of the materials used in electrical insulation are organic in nature and are therefore susceptible to deterioration by heat, oxygen, moisture, and corrosive fumes and liquids. Even the best are vulnerable if incorrectly used or applied, or if machines are used beyond their normal rating. The process by which a coil, winding, armature, or stator is insulated has fully as much influence on the expected life as the properties of the varnish, compound, or treating material itself…Insulation breakdowns are most often the result of internal or external heat and moisture. The heating causes chemical changes in the insulation that are aggravated by the presence of moisture…Aging or "wearing out" of the insulating material results largely in mechanical failures. Electrically the material does not wear out until breakdown occurs, which is usually after the material has become quite brittle and cracked. Aging increases rapidly with temperature, approximately doubling for each 10 C increase. High temperature causes the dehydration of all cellulose materials, resulting in a tendency to char. These effects lead to brittleness, cracking, and shrinkage under vibration and stress, and ultimate crumbing and disintegration of the coating. The shrinkage causes the coils to loosen in the slots, and increases abrasion due to the movements of the coils under electrical forces." (How to Maintain Electric Equipment -Insulation, General Electric, 1950)

"Asbestos is used in electrical paper insulation because of its high thermal and electrical resistance that permit the paper to act effectively as an insulator and to protect the conductor from

fire at the same time. Asbestos electrical insulation is composed of 80 to 85 percent asbestos fiber encapsulated in high temperature organic binders. It is formed on conventional papermaking machines and may be obtained in rolls, sheets, and semi-rigid boards (ICF 1986). The major use of asbestos electrical paper is insulation for high temperature, low voltage applications such as in motors, generators, transformers, switch gears, and other heavy electrical apparatuses. Typically, operating temperatures are 250°Fto 450°F (ICF 1986).” (ICF, 1989)

The recommended practice for cleaning electrical motors is stated “[d]ry dirt, dust, or carbon should be first be vacuumed -without disturbing adjacent areas or redistributing the contamination…After the initial cleaning with the vacuum, high-velocity air may be used to remove remaining dust…Great clouds of dust may fill the sir during this operation so, where possible, operate the machine at low speed to permit maximum dust removal. Also continue vacuum cleaning to prevent contamination of the machine or adjacent equipment. Compressed air is to be clean and free from oil and water.” (General Electric, Instuctions-MD-600) In addition, General Electric recommends that “[w]hen cleaning an assembled machine, as much contaminant as possible should first be removed by suction. Loosen called material by rubbing with fiber or bristle brush (not wire bristles) or with lint-free cloths. Dry, compressed air may be used to remove material not reached by brush or cloth; however, the direction of the air blast should be controlled to prevent re-depositing the contaminant in an even more inaccessible part of the machine.” (General Electric, Instructions for Large Motors and Generators)

The general manor of exposure to asbestos by people conducting maintenance on motors is during cleaning when the people used the recommended method of using compressed air to blow out dust from the interior of the motors. While exposure studies of the levels of exposure of using compressed air to blow out motors is unavailable, there is ample literature reporting the exposure related to a similar process of using compressed air to blow out dust in the brake repair industry.

In a review by Lemen, it was reported that “chrysotile asbestos was found in all dust samples taken from car brake drums, with 2-15% in each sample in both fiber and fibril forms, with average concentrations from blowing the dust of 16 fibers/ml of air…” with measurable

concentrations found 75 feet away. (Lemen, 2004) Rohl reports that exposure ranges and means, reported in f/ml (PCM), from friction products during automotive brake repair include blowing dust from brake drums at a distance from 1 – 1.5 meters (m), in which the range was 6.6 to 24.9 f/ml with an average of 15.0 f/ml (n=4); at a distance from 1.5 – 3 m, in which the range was 2.0 to 4.2 f/ml, with an average of 3.3 f/ml (n=3); and at a distance from 3 – 6 m, in which the range was 0.3 to 4.8 f/ml with an average of 1.6 f/ml (n=2). Background samples collected 5 minutes after air jet blowing at a distance of 3.6 – 16 m, revealed a range from 0.1 f/ml to 0.2 f/ml with an average of 0.2 f/ml (n=2). Background samples collected 7-14 minutes after “air jet blowing” at a distance of 19.6 – 22.6 m, revealed an average of 0.1 f/ml (n=2). (Rohl, 1977) In a review to the EPA titled “Asbestos Dust Control in Brake Maintenance”, exposure levels, reported in f/cc (PCM), from working with asbestos-containing brake products are reported. The use of a compressed air gun for several studies resulted in a range of 0.14 to 2.69 f/cc with a TWA of 0.03 f/cc and an average peak level of 0.71 f/cc; a range of 0.91 to 15.0 f/cc with a TWA of 0.13 f/cc and an average peak level of 4.87 f/cc; a range of 6.6 to 29.8 f/cc with an average peak level of 16.00 f/cc; a level of 0.85 f/cc; a level of 0.33 f/cc with a TWA of 0.4 f/cc; and a range of 0.6 to 3.00 f/cc with an average peak level of 1.43 f/cc. (PEI Associates, 1985) In another study, compressed air blown onto a wheel and brake assembly reported area levels at 3.17 and 2.48 f/cc (PCM), 5.39 and 11.75 (Fibers > 5µm/cc, TEM), respectively. Personal samples ranged from 4.13 to 16.52 f/cc (PCM) (n=4) and <8.32 to 33.71 (Fibers > 5µm/cc, TEM) (n=4), respectively. (Longo, 1998) In another similar report produced by Hatfield and Longo, they “conducted a study to determine exposures to airborne asbestos fibers generated while performing compressed air blowout on a brake assembly that contained non asbestos brake shoes, but contained residual asbestos contaminated brake dust from the previous shoe friction material.” During the “1st Wheel Blowout” area samples ranged from 0.04 to 0.09 f/cc (PCM) (n=4), 1.32 to 3.98 (Fibers ≥ 5µm/cc, TEM) (n=4); while personal samples ranged from 0.52 to 1.03 f/cc (PCM) (n=4), 6.71 to 6.77 (Fibers ≥ 5µm, TEM) (n=4). During the “2nd Wheel Blowout,” area samples ranged from 0.07 to 0.11 f/cc with one sample overloaded (PCM) (n=4) and “None Detect” to 7.83 (Fibers ≥ 5µm, TEM) (n=4); personal samples ranged from 0.56 to 1.72 f/cc (PCM) (n=4) and 6.77 to 40.63 (Fibers ≥ 5µm, TEM) (n=4). Thirty minutes after compressed air use, area samples ranged from

0.01 to 0.03 f/cc with one sample overloaded (PCM) (n=4) and 0.19 to 0.96 (Fibers ≥ 5μm, TEM) (n=4). They concluded that "[d]uring this process, significant amounts of asbestos fibers are released into the air." (Hatfield, 2001)

20. Asbestos-containing Floor Tile

"The exact composition of vinyl-asbestos floor tile varies by manufacturer. Typical ranges for the percentage of each constituent are: asbestos 5-25%" (ICF, 1989) "Raw materials are mixed by a tumbling action. The specifications generally call for approximately 25 percent asbestos." (Williams, 2003) Asbestos-containing vinyl floor tile asbestos content was reported between 10-34% during a 1990 study. (Hays, 1990) EPA report in a "Summary of Asbestos-Containing Products" that Flooring tile and Sheet Goods contained 21 to 33 % asbestos from 1920 to 1990. (EPA, NESHAP, 1990)

In a 1990 presentation of a study, double layers of VAT were removed from each of two schools in different cities (Project One and Project Two). Removal was conducted within a negatively pressured area in relation to other non-work areas, and VAT was removed "via wet, manual scraping techniques and solvent was used for residual mastic removal. Project One bulk sample analysis averaged 15% chrysotile while Project two bulk sample analysis averaged 34% chrysotile. Project One, areas samples averaged 0.0199 s/cm^3 (n=6) TEM; Project Two area samples averaged 0.015 f/cm^3 (n=4) PCM and 0.366 s/cm^3 (n=4) TEM. In this same presentation another project (Project Three) involved the removal of 4,000 square feet of VAT and mastic from a school gymnasium. VAT was removed "via scrapers and the residual mastic was removed with solvents. Average bulk analysis of VAT was 10% chrysotile. Air sampling during removal did not occur. The first round of clearance sampling concluded failure, airborne concentrations reported as <0.01 f/cm^3 (n=5) PCM and 0.028 s/cm^3 (n=5) TEM. Another round of clearance sampling after a re-clean revealed and average of <0.003 s/cm^3 (n=5) TEM with no asbestos fibers detected. With regard to VAT, the presenter concludes "[a]irborne fiber levels generated during VAT removals may be at least an order of magnitude higher when analyzed and counted by the NIOSH 7400 PCM method. The data indicate a predominance of structures

smaller than those which are counted by the PCM method. Since medical science is unclear on the health effects of structures less than 5.0 micrometers in length, respiratory protection should be designed to address these small structures.” (Hays, 1990)

In a 2003 Williams study, the removal of vinyl asbestos floor tile and asbestos sheet flooring using the 1995 Recommended Work Practices from the Resilient Floor Covering Institute (RFCI) control methods were reported in PCM and TEM. The removal of 12 x12” vinyl floor tile (4-8% chrysotile TEM) and mastic (5-8% chrysotile PLM) in a commercial building resulted in in the following PCM and TEM data: Area1 with RFCI methods resulted in a range from <0.003 to 0.005 f/cm^3 (n=5) and 0.023 to 0.294 s/cc (n=5); Area 2 with RFCI methods resulted in a range from <0.006 to 0.009 f/cm^3 (n=5) and 0.035 to 0.147 s/cc (n=5); Area 3 with more aggressive techniques resulted in a range of 0.005 to 0.012 f/cm^3 (n=5) and 0.051 to 0.083 s/cc (n=5). The removal of 9 x 9” asphalt floor tile (1-3% chrysotile PLM, 12-19% chrysotile TEM) and mastic (7-10% chrysotile PLM) in a school cafeteria resulted in in the following PCM and TEM data: Area1 with RFCI methods resulted in a range from 0.011 to 0.014 f/cm^3 (n=5) and 0.071 to 0.294 s/cc (n=5); Area 2 with RFCI methods resulted in a range from 0.008 to 0.012 f/cm^3 (n=5) and 0.104 to 0.332 s/cc (n=5); Area 3 with more aggressive techniques resulted in a range of 0.011 to 0.015 f/cm^3 (n=4) and 0.148 to 0.174 s/cc (n=4). (Williams, 2003)

21. Conclusions

A. According to sections 8-20, when these asbestos-containing products were installed, removed, cut, manipulated, repaired, or in any way disturbed, workers and bystanders were exposed to significant airborne concentrations of asbestos.

B. Airborne asbestos does not settle quickly from the air and can easily become re-entrained after it does settle.

C. Evidence of the use or misuse of adequate engineering controls and/or respiratory protection may affect exposure to airborne asbestos fibers.

D. We accept the right to make further opinions on asbestos-containing products not mentioned in this report.

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APPENDIX A

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20. Asbestos-containing Floor Tile

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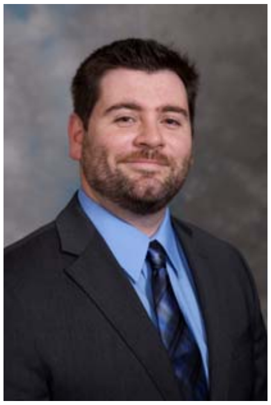
APPENDIX B

GOBBELL HAYS PARTNERS, INC.
ARCHITECTURE • ENGINEERING
ENVIRONMENT • HEALTH • SAFETY



KENNETH S. GARZA, CIH, MS
Project Manager

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San Antonio, Texas 78230
Phone – 210-824-5600
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Nashville
Denver
San Antonio
Palm Beach Gardens

EDUCATION:
Bachelor of Science in Biology, Minor in Chemistry, St. Mary's University, San Antonio, 2001
Master of Science in the Environmental Science and Management, University of Texas at San Antonio, 2006

LICENSES AND CERTIFICATIONS:
Certified Industrial Hygienist, #10082
Texas Licensed Asbestos Consultant, #105702
Texas Licensed Mold Assessment Consultant, #MAC0379

PROFESSIONAL SUMMARY:
Mr. Garza has ten years of experience in various aspects of the environmental industry which include:

Conducting numerous inspections for the determination of asbestos-containing materials, and the development of abatement protocols for the removal of asbestos-containing materials, asbestos dose reconstruction.

Conducting numerous microbial investigations with an emphasis on causation. In addition, he has conducted numerous visual inspections for the purpose of developing Microbial Remediation Plans, as well as the composition of those plans. Conducting numerous remediation projects from the selection of the contractor to the receipt of satisfactory post remediation samples and closeout reports. Conducting Legionella sampling and evaluation.

Conducting classic Industrial Hygiene (IH) field work for purpose of identifying harmful agents to occupants in the residential and occupational setting. These agents include, but are not limited to, formaldehyde, xylene, respirable dust, carbon black (soot), fly-ash, volatile organic compounds (VOC's), nicotine residue, pesticides, inorganic acids, sodium hydroxide, trichloroethylene, chromic acid, and ammonia. Literature research related to environmental and industrial hygiene issues.

Client Base: Healthcare, Hospitality and Insurance Industries; School Systems, Commercial and Residential Properties, Law Firms.

MEMBERSHIPS:
Alamo Chapter, Air and Waste Management Association, 2004-2009, 2012
Texas Association of Health Care Facilities Management, 2007-2009
North Chamber of Commerce, San Antonio, 2009
American Industrial Hygiene Association, 2009-2012

PUBLICATIONS:
Garza, Kenneth S. "The Use of Blue Crocidolite in a 'Salt Cake' Plant." The Official Newsletter of the Environmental Information Association (EIA); Volume 11, Issue 3, May/June 2012.

Stephen D. Kenoyer, MS
GOBBELL HAYS PARTNERS, INC.
Environmental Scientist/
Industrial Hygienist
8207 Callaghan Road, Suite 350
San Antonio, Texas 78230

EDUCATION:

1990 - Bachelor of Science in Physics
University of Texas at San Antonio

1992 - Master of Science in Environmental Science
University of Texas at San Antonio

CURRENT LICENSES AND CERTIFICATIONS:

Texas Mold Assessment Consultant
40-Hour HAZWOPER

PREVIOUS LICENSES AND CERTIFICATIONS:

Texas Licensed Asbestos Project Manager
Texas Licensed Asbestos Inspector
Texas Licensed Asbestos Air Monitoring Technician
Texas Certified Lead Risk Assessor

PROFESSIONAL SUMMARY:

Mr. Kenoyer has twenty years of experience in various aspects of the environmental industry.

Mr. Kenoyer has provided expert testimony for asbestos exposure and asbestos exposure reconstruction assessments. He has conducted numerous exposure reconstruction assessments associated with lawsuits involving asbestos and formaldehyde. Expert industrial hygienists with Gobbell Hays Partners Inc. routinely rely upon these assessments when providing sworn testimony. He is experienced with Monte Carlo Simulations while constructing exposure reconstruction assessments.

Mr. Kenoyer has conducted numerous indoor air quality assessments in hospital and commercial buildings, which includes temperature and humidity complaints, particulates, and VOCs. Mr. Kenoyer has conducted numerous *legionella* outbreak assessments including making remedial recommendations. Mr. Kenoyer has conducted and managed multiple chemical exposure assessments in residential and commercial settings.

Mr. Kenoyer has conducted, supervised, and written numerous Phase I Environmental Site Assessments through the States of Texas, Florida, Indiana, and Oklahoma. He has also conducted numerous Phase II Hazard Assessments of asbestos and lead, including the writing of reports and recommendations, developing Operation and Maintenance Programs, and the development and implementation of Remediation Specifications. Mr. Kenoyer has directly supervised asbestos and lead inspectors, project managers, and air monitor technicians during multi phase projects involving asbestos and lead abatement.

PRESENTATIONS:

"Interpretation of South Texas Airborne Fungal Data," presented at the 21st Annual Conference and Exposition of the Environmental Information Association, Las Vegas, NV, March 23, 2004.

"Texas Asbestos Dose Reconstruction from an Expert's Perspective," presented at ASTM Johnson Conference, Burlington, VT, July 28, 2011.

PUBLICATIONS:

"Characterization of Coal Ash Including Fly Ash Particles" by J. R. Millette1, W. L. Turner Jr., S.M. Hays, S. Kenoyer, S. Compton, W. B. Hill, and P. S. Chepaitis. Expected publication, October 2012.

COURSES/SEMINARS:

- Investigating and Assessing Biological and Microbiological Contamination in the Indoor Environment sponsored by the Texas Department of Health, Austin, Texas
- Strategies for Conducting Meaningful Microbial Investigations sponsored by the American Indoor Air Quality Council, Phoenix, Arizona
- How to Conduct a Legionella Risk Assessment presented by the MidAtlantic Environmental Hygiene Resource Center, Ft. Lauderdale, Florida.

APPENDIX C

Testimony/Deposition Experience Since 2009 (Updated January 21, 2013) – Kenneth S. Garza

Client or Attorney & Location	Case Number	Names of Parties	Where Case was Filed	Deposition	Trial	GHP Project Number
Law Offices of Pries & Roy, PLC.	Civil Action No. 4:08-CV-03340	Doctor's Hospital 1997, L.P., et al. v. Beazley Insurance Co., Inc.	The United States District Court for the Southern District of Texas Houston Division	Yes 7/01/2009	Yes 2/17/2010	08214.00
Law Office of Simon Eddins & Greenstone, LLP.	Cause No. 2008 - 58697	Roy Legget and Wanda Legget v. Bondex International, Inc., et al.	District Court, Harris County, Texas, 11th Judicial District	Yes 4/14/2009	None	07079.06
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Jessie Leonard v. AC&S, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.00
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Charles King v. AMCHEM, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.01
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Jimmie Dale Davis v. AMCHEM, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.02
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Raymond Stevens v. AMCHEM, Inc., et al.	Eastern District of Virginia, Newport News Division	Yes 3/8/2011	Pending	10307.03
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Robert Jacobs v. AC&S, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.04
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Lawrence G. Parham v. AC&S, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.05
Law Offices of Paul A. Weykamp	Civil Action No. MDL 875	Phillip E. Holmes v. AC&S, Inc., et al.	Eastern District of Pennsylvania	Yes 3/8/2011	Pending	10307.06

Testimony/Deposition Experience Since 2009 (Updated January 21, 2013) – Kenneth S. Garza

Client or Attorney & Location	**Case Number**	**Names of Parties**	**Where Case was Filed**	**Deposition**	**Trial**	**GHP Project Number**
Cascino Vaughan Law Offices	MDL Docket No. MDL 875	Anderson v. Bechtel Corporation, et al.	United States District Court for the Eastern District of Pennsylvania	Yes 12/13/2011	Pending	11266.01
Morgan & Morgan, LLC	C.A. No. 11C-02-034 ASB	Donald Strefling, Barbara Strefling v. Advanced Auto Parts, et al.	The Superior Court of the State of Delaware in and for New Castle County	Yes July 24, 2012	None	10303.06
Morgan & Morgan, LLC	Civil Action No. 03-C-9600	Patricia D. Little, et al. v. A.O. Smith Corporation, et al.	Circuit Court of Kanawha County, West Virginia	Yes, January 15, 2013	Pending	10303.07
Morgan & Morgan, LLC	Civil Action No. 12-C-922 KAN	Ellen Thompson, et al. v. A.O. Smith Corporation, et al.	Circuit Court of Kanawha County, West Virginia	Yes, January 15, 2013	Pending	10303.08

Expert Testimony Experience – Stephen Kenoyer, Environmental Scientist/Industrial Hygienist

Client or Attorney & Location	Cause Number	Names of Parties	Where Case was Filed	Deposition	Trial
Akin Gump Strauss Hauer & Feld, L.L.P	02-4398-D	Terry Panknin and Patricia Panknin v. State Farm Lloyds, et al	105th Judicial District Court of Nueces County, Texas	Yes 07/31/03	No
Huseman and Pletcher	03-60285-00-0-4	Venus W. Womack and Peter S. Rudellat v. State Farm Lloyds, et al.	County Court of Law No. 4, Nueces County	Yes 10/11/04	No
Law Office of Ward Thomas Corpus Christi, Texas	Unknown	Sutherland v. State Farm	Unknown	Arbitration 12/6/04 – 12/8/04	No
Womble Carlyle Sandridge & Rice	01-4238-E	William B. Miller, et. al. vs. Bodine-Scott Air Conditioning Company, et. al.	148th Judicial District, Nueces County, Texas	Yes 4/2/05	No
Timothy D. McMurtrie Royston, Razor, Vickery Williams, L.L.P.	02-4652-B	Phillip Denniston, et al vs. Allstate Texas Lloyd's et al.	117th Judicial District, Nueces County, Texas	Yes 4/7/05	No
Woodke & Gibbons, P.C., L.L.O.	CI 03-2913	Greg MacLean et. al vs. Don Williams, et al	District Court of Lancaster County, Nebraska	No	Yes 9/20/06 – 9/21/06
Waters & Kraus, LLP	2:11-CV-60070-ER	Joe P. Freeman and Gloria K. Freeman vs. AMF Inc., et. al.	U.S.D.C. - Eastern District of Pennsylvania	Yes 8/2/11	No
Cascino Vaughan Law Firm	MDL Docket No. 875	Paul Gehrt – EDPA CA#08-92066	U.S.D.C. - Eastern District of Pennsylvania	Yes 11/29/11	No
Cascino Vaughan Law Firm	MDL Docket No. 875	Marion Goeken – EDPA CA#10-68122	U.S.D.C. - Eastern District of Pennsylvania	Yes 11/29/11	No
Cascino Vaughan Law Firm	No. 10-CV-021813	Dawn Weber v. Carpenter Brothers, Inc., et al.	Milwaukee County Case	Yes 05/15/12	No
Sales Tillman Walbaum Catlett & Satterley	2010-CI-07125	Julia Ann Mindel, et al., v. General Electric Company	Common wealth of Kentucky, Jefferson Circuit Court	Yes 07/31/12	No

Expert Testimony Experience – Stephen Kenoyer, Environmental Scientist/Industrial Hygienist

Client or Attorney & Location	Cause Number	Names of Parties	Where Case was Filed	Deposition	Trial
Cascino Vaughan Law Firm	MDL Docket No. 875	Homer C. Patrick v. The Anaconda Company, et al.	U.S.D.C. - Eastern District of Pennsylvania	Yes 10/30/12	No
Cascino Vaughan Law Firm	MDL Docket No. 875	Cleora L. Schmidt, et al., v. A.C. And S., Inc., et al.	U.S.D.C. - Eastern District of Pennsylvania	Yes 10/30/12	No

APPENDIX D

COMPENSATION

Employee	Title	Compensation
Stephen D. Kenoyer	Environmental Scientist/Industrial Hygienist	$165.00 per hour
Kenneth S. Garza	Environmental Scientist/Industrial Hygienist	$165.00 per hour
Steve M. Hays	Principal CIH, Non-Litigation	$275.00 per hour
Steve M. Hays	Principal CIH, Litigation	$295.00 per hour